THE NUMBER AND DISTRIBUTION

OF

MICRO-ORGANISMS IN THE AIR OF THE BOSTON CITY HOSPITAL,

WITH SOME

CARBONIC ACID DETERMINATIONS.

By GREENLEAF R. TUCKER, S. B.

THE NUMBER AND DISTRIBUTION

OF

MICRO-ORGANISMS IN THE AIR OF THE BOSTON CITY HOSPITAL,

WITH SOME

CARBONIC ACID DETERMINATIONS.

By GREENLEAF R. TUCKER, S. B.

The object of this investigation was to determine the number and distribution of the micro-organisms in the air of the Boston City Hospital; to ascertain the causes affecting their number and distribution; and to examine, as far as possible, the character of the organisms present. A study of the germs themselves was soon found to be impracticable, and it was thought advisable to reserve this part of the subject for future investigation. Transfers of colonies from the air of the wards, to the number of about two hundred, have been made and preserved for this purpose. It is believed that these cultures will represent most of the forms habitually present in the air of these buildings.

The experiments to be described began in November, 1888, and were continued uninterruptedly for a period of three months. Some regret is felt that a portion of the work at least could not be conducted under the conditions of weather to be expected at that time of year. The winter was exceptionally mild, and the ground practically free from snow.

The investigation of indoor air began by taking samples in the afternoon, between two and three o'clock; the time being so chosen because the wards are then in their normal condition, only such work being done as the necessities of

the sick demand. On Monday, Tuesday, Thursday and Saturday of each week, friends of patients are admitted from two to three P.M., usually to the number of two to three hundred, and distribute themselves throughout the various wards, the number of visitors in each ward being often equal to the number of patients; this afforded opportunity to observe the effect upon the air of increased numbers of people, over those habitually present. It was found necessary to limit the number of experiments each day to five, including the outside air. The total number of wards being eighteen, four or five days elapsed before a return could be made to a given point; and the entire month was necessary to accumulate sufficient data for each ward, from which to draw conclusions.

During December, samples were taken mornings, generally between eight and ten o'clock, the wards at that time being in a more or less disturbed condition,—beds are made, floors swept, surgical dressings changed, and the general comfort of the patients attended to. By following this plan, two series of results were obtained, showing the condition of the air under quiet and disturbing influences. The month of January and part of February were devoted to special investigation, which the previous work had shown to be necessary.

Methods employed in the Quantitative Determination of Micro-organisms in the Air.

The introduction by Koch in 1881 of a solid-culture medium for the study of micro-organisms has resulted in methods by which we can determine with facility, and approximately, if not with accuracy, the number of micro-organisms in the air. Koch himself exposed plates coated with a solid nutrient gelatine, upon which aerial microbes settled, and could be counted after development. Hesse, however, was the first to apply this principle quantitatively to investigations of the air, and in 1883 published the well-known method bearing his name. Petrie, in Germany, and Frankland, in England, have proposed methods, which, while retaining the solid-culture medium of Koch, differ essentially from the method of Hesse and from each other, in detail. In this

country, also, some new methods of culture have been practised by the writer, in conjunction with Professor Sedgwick, in a series of investigations conducted at the Massachusetts Institute of Technology.*

Hesse's Method.

Hesse makes use of the fact previously ascertained, — that micro-organisms rapidly settle out in a quiet atmosphere. He employs a long glass tube of large bore, coated inside with sterilized nutrient gelatine. The tube is fastened to a photographic tripod in a horizontal position, and, by a suitable connection with two aspirator-bottles, a slow current of air (one litre in three minutes) is drawn through the tube. The germs are all supposed to settle out during the passage of the air through the tube, and remain fixed by the moist, solid gelatine, where they become visible after several days as isolated colonies.

Frankland's Method.

This method consists in aspirating a known volume of air through a glass tube containing two sterile plugs of glass-wool alone, or glass-wool and fine sugar-powder; after which the germ-laden filter is transferred to a flask containing melted sterilized nutrient gelatine, the two thoroughly shaken together, and solidified upon the sides of the flask by cooling, where the colonies which develop can be counted.

Petrie's Method.

Petrie uses fine sand as a filter, packed in a small glass tube, and held in place by disks of wire gauze. After drawing through sufficient air by means of an air pump, the sand, with its occluded germs, is poured into several small double dishes of glass, containing nutrient gelatine, the object being to distribute the sand and germs over a considerable surface, so that the colonies may be more readily counted.

The method employed in the present investigation was first used by the writer, in association with Professor Sedg-

* See foot-note on page 164.

wick,* in a series of experiments in 1887, and will be described somewhat in detail.

The actual requirements of a quantitative method for the bacteriological examination of air, briefly stated, are as follows: —

First. — A means of collecting and accurately measuring the volume of air to be examined.

Second. — A suitable filtering medium for holding back the micro-organisms contained in the air.

Third. — A solid-culture medium, in which the germ-laden filter can be diffused, and where, on cooling and incubating for a sufficient length of time, the germs may develop and be counted as isolated colonies.

The apparatus consists essentially of three parts: (1) A glass tube of special form, to which the name of *aerobioscope* has been given (see Fig. 1); (2) a stout copper cylinder of about sixteen litres capacity, provided with a vacuum gauge (see Fig. 2); (3) an air pump. The *aerobioscope* through which the air is aspirated is six inches long, and one and three-quarters inches in diameter at its expanded part; the upper end of it is narrowed somewhat to a neck one inch in diameter and one inch long. To the lower end is fused a piece of glass tubing six inches long and three-sixteenths of an inch in bore, in which to place the filtering material.

Preparation of the *aerobioscope*: Upon the narrow part of the tube, two inches from the lower end, a slight mark is made with a file, and a little roll of brass gauze is inserted, which serves as a stop for the filter to be placed above it. Beneath the gauze stop is placed a small plug of cotton wool, and the open ends are then plugged with cotton wool; the tube is now placed in a sterilizer, and subjected to a heat of at least 150° C. for one or two hours. When cool, the non-sterilized cotton-wool plug is carefully removed from the neck, and sterilized No. 50 granulated sugar is poured in, until it just fills the four inches of narrow tube above the gauze stop. This column of sugar weighs one gramme and is the filtering material employed to engage and retain the

* The complete paper was presented to the National Academy of Sciences at Washington, April 18, 1888, under the title "A new Method for the Biological Examination of Air: with a description of an Aerobioscope."


Sterilized
Cotton Wool plug
Space for Culture
Etched Lines for Counting
Sterilized Granulated Sugar
Wire Gauze Stop
Cotton Wool
Cotton Wool plug
Ærobioscope

Fig. 1.

micro-organisms. The cotton-wool plug being replaced, the tube is again placed in the sterilizer, and re-sterilized for several hours at 120° C.

Taking the air sample: In order to measure the amount of air used, the value of each degree on the vacuum gauge is determined in terms of air, by means of an air meter, or by calculation from the known capacity of the cylinder. This fact ascertained, the negative pressure indicated by the needle on exhausting the cylinder shows the volume of air which must pass into it to fill the vacuum. By means of the air pump, one exhausts the cylinder until the needle reaches the mark corresponding to the amount of air required. A sterilized *aerobioscope* is attached to the cylinder, in an upright position, by means of a clamp; and, to establish communication between the two, they are joined together by means of a rubber tube attached to the lower end of the *aerobioscope* and to a stop-cock on the cylinder. For removing and protecting the sterilized cotton-wool plug while the air is being drawn through the tube, a very simple device is used. A glass shield with a neck slightly larger than the neck of the *aerobioscope*, and bearing a rubber finger-cot, is pushed down over the cotton-wool plug; when, by compressing the rubber, the plug can be removed (inside the shield), and remains suspended there. The plug removed, the cock is opened, when air will pass through the *aerobioscope*, leaving its germs in the sterilized sugar filter.

Cultivation of the germs: The *aerobioscope*, after the air has been drawn through, is taken to the culture room for further treatment. The tube being held in a nearly horizontal position, the sugar (with the contained germs) is made to run into the body of the tube, by a gentle tapping. Melted sterilized nutrient gelatine (25 cc.) is now added, under proper precautions, and the neck closed with a perforated sterilized rubber stopper, plugged with cotton wool. On rotating the tube, the sugar all dissolves in the gelatine, leaving the germs uniformly distributed through it. The gelatine is now congealed in an even film upon the inside of the tube, where, after four or five days, the colonies will develop, and can be counted by the aid of squares engraved upon the glass.

The following cut shows the apparatus set up ready for use : —

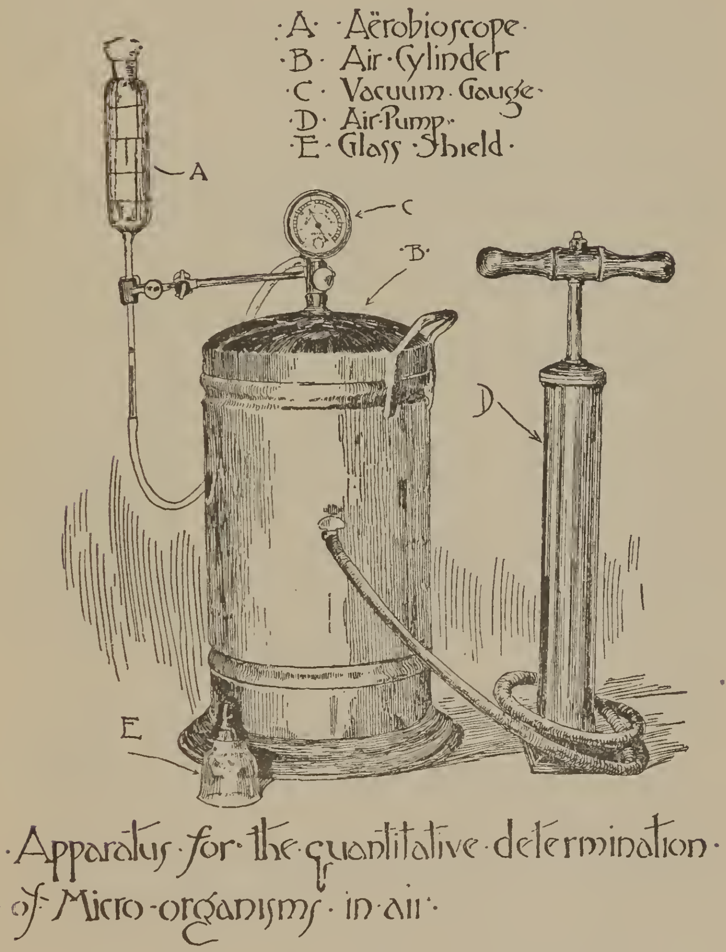


Fig. 2.

This method has several advantages not to be found in other methods. In the first place, the use of a vacuous cylinder permits a known volume of air to be aspirated with great ease, and the rate of flow through the filter is controlled to a nicety. The advantage of a soluble filter (sterilized granulated sugar), leaving only the germs imbedded in the gelatine, cannot be overestimated; for any insoluble substances seriously interfere with the counting. Again, the

aerobioscope, quite apart from the filter, constitutes an important advance, since it obviates the necessity of transferring the filter (and contained germs), thereby avoiding accidental loss or gain of germs. The whole apparatus is portable, and the method, as compared with others, is exceedingly rapid of execution.

Outside Air.

In order to have data for comparison with the work done indoors, the outside air was examined nearly every day during this investigation. The results are of some value in themselves, as showing the condition of the air of Boston in a rather secluded place, but in the immediate vicinity of its traffic.

The samples were all taken at the same place, at the foot of the surgical steps, four feet from the ground, on the north side of the hospital, except on rainy days, when the apparatus was moved under the steps, to avoid annoyance from the rain. The direction and strength of the wind, temperature, time of day, and any disturbing influences likely to affect the results, were observed. The ground was free from snow and the weather was mild throughout, while the prevailing winds were strong. The general averages for the months of November and December, 1888, and January, 1889, are shown in the following table: —

Date.	Number of Experiments.	Average number of Bacteria.	Average number of Moulds.	Ratio of Bacteria to Moulds.
November, 1888, . .	19	10.4	6.8	1.5
December, 1888, . .	22	14.5	5.6	2.6
January, 1889, . .	15	13.2	3.5	3.8

All figures representing bacteria and moulds are for 10 litres of air.

The average number of bacteria are thus seen to be about the same for the three months, and representing, as they do, less than two per litre of air, must be considered small. Carnelly (Phil. Trans. of the Royal Society of London, vol. 178) found recently in the town of Dundee, in quiet places, as a mean of fourteen experiments, less than one bacterium per litre of air; while, in certain streets where the ratio of

bacteria to moulds was very high, the total number of organisms was 17.5 per litre of air.

A comparison between the numbers of organisms found on clear and on rainy days is shown in the next table: —

Condition of Weather.	November. Number of Determinations.	November. Average Number of Bacteria.	November. Average Number of Moulds.	December. Number of Determinations.	December. Average Number of Bacteria.	December. Average Number of Moulds.	January. Number of Determinations.	January. Average Number of Bacteria.	January. Average Number of Moulds.
Rain, .	5	7.6	7.8	3	9.3	6.3	2	2.5	3
Clear, .	14	11.4	6.4	18	15.0	5.4	9	19.0	3.5

The number of bacteria present in the air on clear days is greater than on rainy days, but the number of moulds remains the same; *i. e.*, rain washes out bacteria from the air, but does not remove moulds. Both bacteria and moulds were more numerous on rainy days than was expected; and this is perhaps accounted for by the fact that the experiments were made under some stone steps, near a basement door frequently opened by employees.

No deductions could be drawn from the effect of the direction of the wind upon the micro-organisms, owing to the position of the buildings. The quarter from which the wind blew was taken from a neighboring weather-vane; but the direction, as felt by the observer, seldom coincided, being generally either easterly or westerly. The effect of the strength of the wind is, however, worthy of notice, being to increase the numbers of bacteria.

	November. Number of Determinations.	November. Bacteria.	November. Moulds.	December. Number of Determinations.	December. Bacteria.	December. Moulds.	January. Number of Determinations.	January. Bacteria.	January. Moulds.
Wind slight, .	2	2.5	18.0	6	12	9.3	2	4.5	3
Wind strong, .	15	11.0	4.3	15	15	4.4	10	17.0	4

The following table gives the full data for all determinations made upon outside air during the month of December, 1888. It shows considerable variation from day to day, not readily accounted for by the surrounding conditions. The disturbing influences incident to a great city are so many, that causes affecting the numbers of micro-organisms in outside air are generally beyond the eye of the observer.

Outside Air. December, 1888.

Date.	Time.	Bacteria.	Moulds.	Remarks.
1	12.45 P.M.	1	5	Wind W., and moderate; almost raining.
3	11.15 A.M.	8	2	Wind W.; clear and cool.
5	10.00 "	0	7	Wind S. W., and gentle; sky overcast; ground damp.
6	11.00 "	75	5	Wind N. W., and strong; cloudy, cool; two teams drove by; considerable walking about.
7	11.25 "	57	8	Wind W.; strong and puffy; clear and cool.
8	11.30 "	1	2	Wind S. W.; moderate.
10	10.35 "	8	33	Wind S. E., and moderate; ground wet.
11	11.10 "	4	3	Wind E., and strong; raining hard.
13	11.45 "	19	3	Wind W., and strong; cold and quiet.
14	9.15 "	17	1	Wind W., and strong; cold and quiet.
15	11.00 "	12	6	Wind W., moderate; cold and quiet.
17	11.30 "	21	13	Wind S., and gentle; raining hard.
18	12.00 M.	3	3	Wind N. W., and strong; snowing a little; ground wet.
20	10.00 A.M.	7	3	Wind N. W., and moderate; cold.
21	–	24	10	Wind S. W., and gentle; sky overcast; quiet.
22	11.35 "	1	2	Wind N. W., and strong; cold; quiet.
24	11.40 "	14	14	Wind S. W., and gentle; very quiet.
25	1.00 P.M.	10	3	Wind S. W., and gentle.
26	11.30 A.M.	3	17	Wind S., and gentle; ground moist; warm.
27	9.50 "	14	6	Wind N. W., and gentle; ground wet.
29	10.15 "	2	1	Wind S. W., and strong; cool and quiet.
31	11.25 "	13	6	Wind S. W., and moderate but puffy; ground moist.
Average, . .		14.5	5.6	

General Description of the Hospital (with Plates).*

The group of buildings which constitute the Boston City Hospital are thirteen in number, nine of which are exclusively devoted to the sick. The hospital is on Harrison Avenue (see plate), and occupies about 292,000 square feet of land. Buildings to the right of the administration building are devoted to the treatment of medical cases, while those to the left are wholly devoted to surgical cases. The two pavilions, medical and surgical, nearest the street (see cut of hospital), are substantially alike in construction. The upper and lower floors are occupied by male patients,

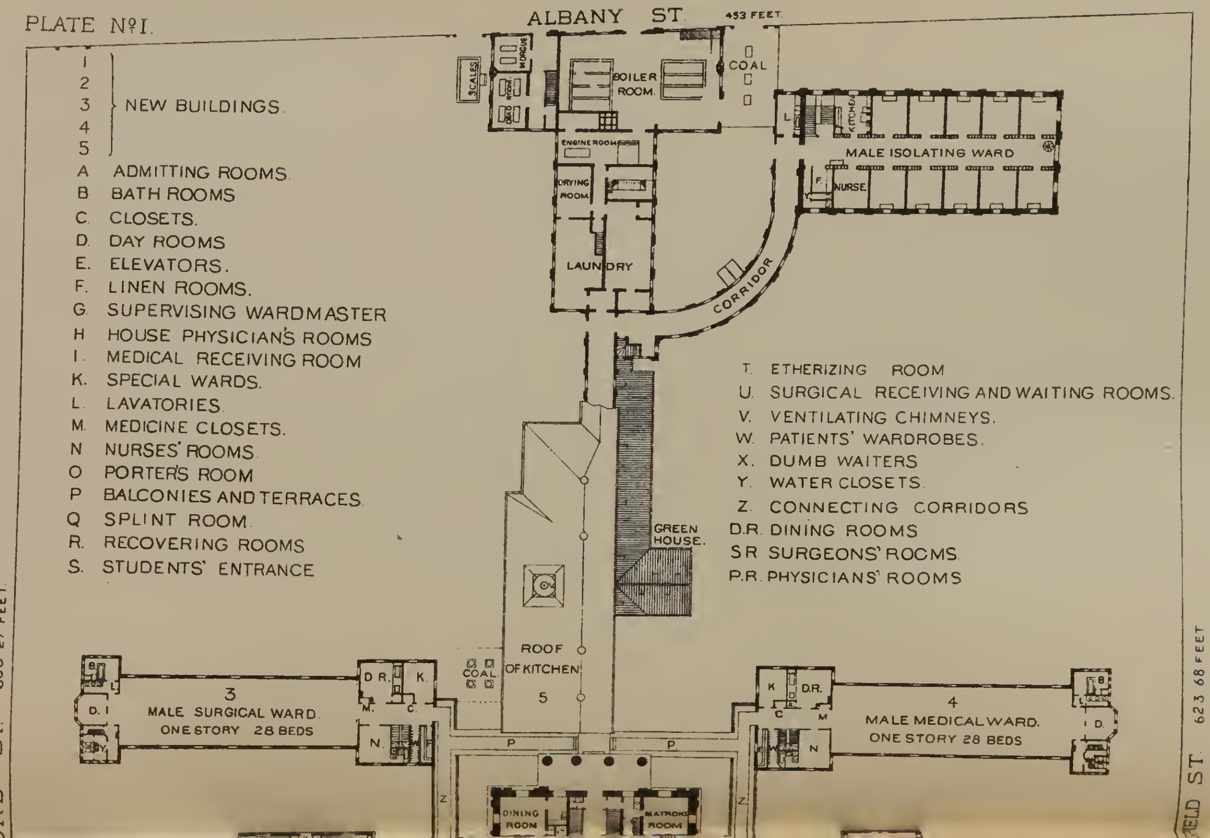
* The descriptions of the hospital appearing in this paper have been taken from the medical and surgical reports of the Boston City Hospital, second series.

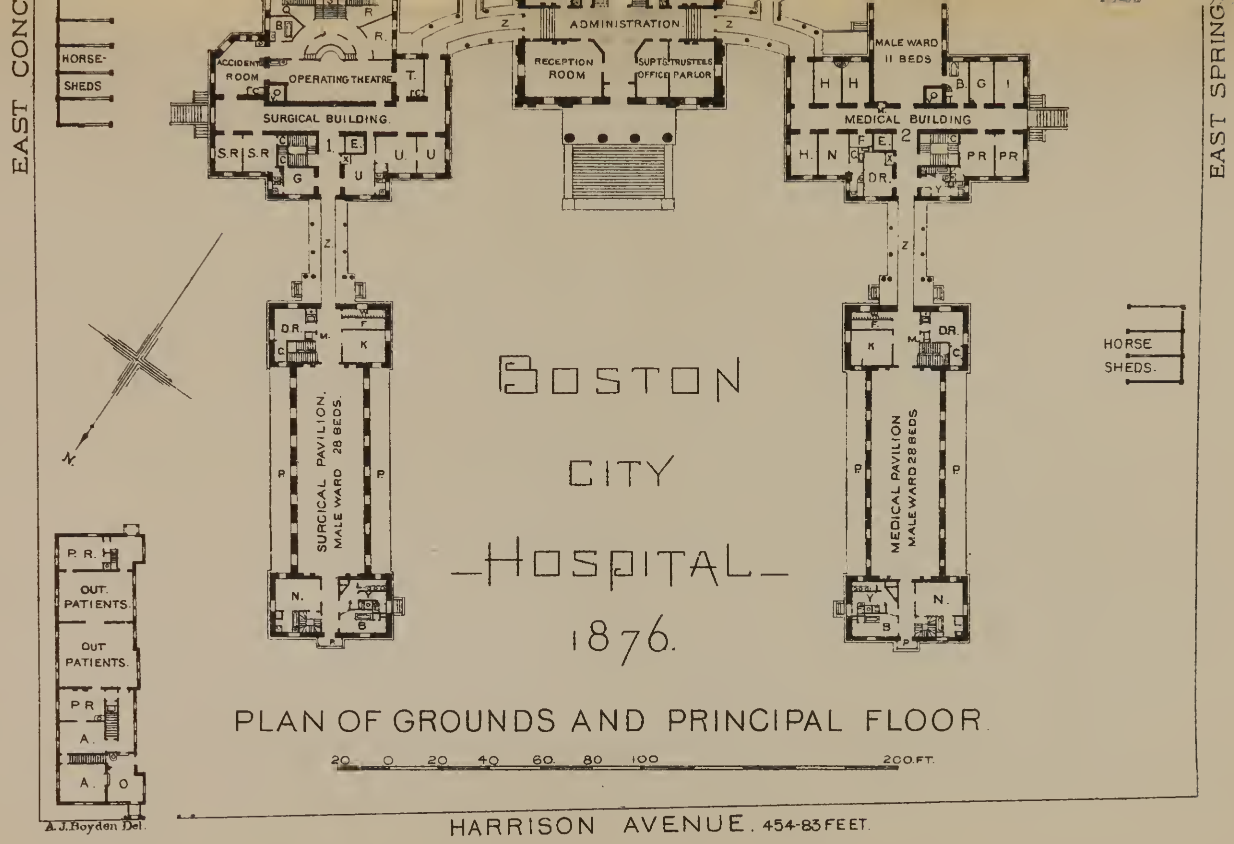
Wards B. C. D. Wards M. N. O. ADMINISTRATION. Wards Q. R. S. Wards F. G. H.

BOSTON CITY HOSPITAL.

HELIOTYPE PRINTING CO. BOSTON

PLATE No. I.


ALBANY ST.
453 FEET.
1
2
3
4
5
NEW BUILDINGS.
A ADMITTING ROOMS.
B BATH ROOMS
C. CLOSETS.
D. DAY ROOMS
E. ELEVATORS.
F. LINEN ROOMS.
G. SUPERVISING WARDMASTER
H HOUSE PHYSICIAN'S ROOMS
I. MEDICAL RECEIVING ROOM
K. SPECIAL WARDS.
L. LAVATORIES.
M. MEDICINE CLOSETS.
N NURSES' ROOMS.
O PORTER'S ROOM
P BALCONIES AND TERRACES.
Q SPLINT ROOM.
R. RECOVERING ROOMS
S. STUDENTS' ENTRANCE
T. ETHERIZING ROOM
U. SURGICAL RECEIVING AND WAITING ROOMS.
V. VENTILATING CHIMNEYS.
W. PATIENTS' WARDROBES.
X. DUMB WAITERS
Y. WATER CLOSETS.
Z. CONNECTING CORRIDORS
D.R. DINING ROOMS
S R SURGEONS' ROOMS.
P.R. PHYSICIANS' ROOMS
SCALES
MORGUE
BOILER ROOM.
COAL
ENGINE ROOM
DRYING ROOM
LAUNDRY
CORRIDOR
KITCHEN
MALE ISOLATING WARD
NURSE
GREEN HOUSE.
ROOF OF KITCHEN
5
COAL.
3
MALE SURGICAL WARD.
ONE STORY 28 BEDS
4
MALE MEDICAL WARD.
ONE STORY 28 BEDS
DINING ROOM
MATRON'S ROOM
ORD ST.
600 27 FEET.
ELD ST.
623 68 FEET


BOSTON
CITY
HOSPITAL
1876.
PLAN OF GROUNDS AND PRINCIPAL FLOOR.
20 0 20 40 60 80 100 200 FT.
HARRISON AVENUE. 454-83 FEET.
EAST CONC
EAST SPRING
ADMINISTRATION.
RECEPTION ROOM
SUPT & TRUSTEES OFFICE PARLOR
SURGICAL BUILDING.
OPERATING THEATRE
ACCIDENT ROOM
MEDICAL BUILDING
MALE WARD 11 BEDS
SURGICAL PAVILION. MALE WARD 28 BEDS.
MEDICAL PAVILION MALE WARD 28 BEDS
HORSE-SHEDS
HORSE SHEDS.
OUT. PATIENTS.
OUT PATIENTS.
N.
A. J. Boyden Del.

the middle floor by females. The pavilions immediately in the rear of the above are also medical and surgical. (Plans of other buildings, not seen in the cut, may be seen in plate No. I.) Pavilions 3 and 4 are one-story buildings. These wards are for male patients only, and contain twenty-eight beds. A two-story brick pavilion contains the male and female isolating wards. There are ten rooms on each floor, opening from a hall or passage way, and designed to accommodate one or more patients. The vacant space between the isolating wards and male medical ward 4 (plate No. I.) is now occupied by two new buildings for contagious diseases. They are totally different from all others of the group, but are themselves essentially alike. Diphtheria and scarlet-fever are at present treated in these wards.

The hospital receives mainly acute cases, with only such chronic cases as the authorities believe can be benefited by a short residence in the hospital. The hospital report for the year 1888 shows the number of patients admitted during the year to be 5,875; of this number, 3,665 were males, 2,210 females; 2,445 were born in the United States, the nativity of the remaining number being divided between thirty-five countries, representing all parts of the globe. The character of the diseases treated in the wards of this hospital, in the course of a year, embraces nearly all known to medical science.

The first two buildings to be described are shown in plate No. I., where they are designated surgical and medical pavilions. A plan of the second and third floors is shown in plates Nos. II. and III. Each pavilion is 148 feet in length, 48 feet in width, and three stories high. On the first, second and third floors are wards, each 80 feet long, $27\frac{2}{3}$ feet wide, the two lower being 16 feet, and the upper 10 feet high. Each ward is lighted by fourteen windows, seven on a side, and is arranged for twenty-eight beds. By considering the data of the two buildings together, we shall have not only a comparison of the wards of each pavilion, but of the two buildings themselves, devoted to two distinct classes of patients, — medical and surgical. In every other way the conditions found in these buildings are identical. The following tables give the average number of

micro-organisms, of five or more determinations in each ward: —

Medical Pavilion.

Afternoons, November, 1888.	Wards. F.	Wards. G.	Wards. H.	Forenoons, December, 1888.	Wards. F.	Wards. G.	Wards. H.
Bacteria, . .	15.8	13.0	33.3	Bacteria, . .	15.2	49.7	62.5
Moulds, . .	9.2	9.0	13.2	Moulds, . .	1.5	1.3	5.2

Surgical Pavilion.

Afternoons, November, 1888.	Wards. B.	Wards. C.	Wards. D.	Forenoons, December, 1888.	Wards. B.	Wards. C.	Wards. D.
Bacteria, . .	6.8	5.6	13.0	Bacteria, . .	24.7	15.8	16.5
Moulds, . .	6.6	2.8	8.2	Moulds, . .	13.5	20.0	26.5

The table shows the following results: —

I. — Bacteria are more abundant in the medical than in the surgical pavilion.

This appears to me to be a very important and significant fact. Here are two buildings exactly alike, all the conditions within being the same, except that in one are medical, in the other surgical, patients. If the organisms come entirely from the outside air, there is no reason why both buildings should not contain practically the same numbers. It seems probable, therefore, that a portion at least of the bacteria found in the medical wards is due to the class of diseases assigned to them.

II. — Bacteria in both medical and surgical wards are more abundant mornings than afternoons.

This is due to the conditions of the wards at the time of experiments. In the morning the disturbing influences are many, — bed-making, sweeping, dusting, changing of surgical dressings, toilet and general care of patients. Such

PLATE Nº 2.

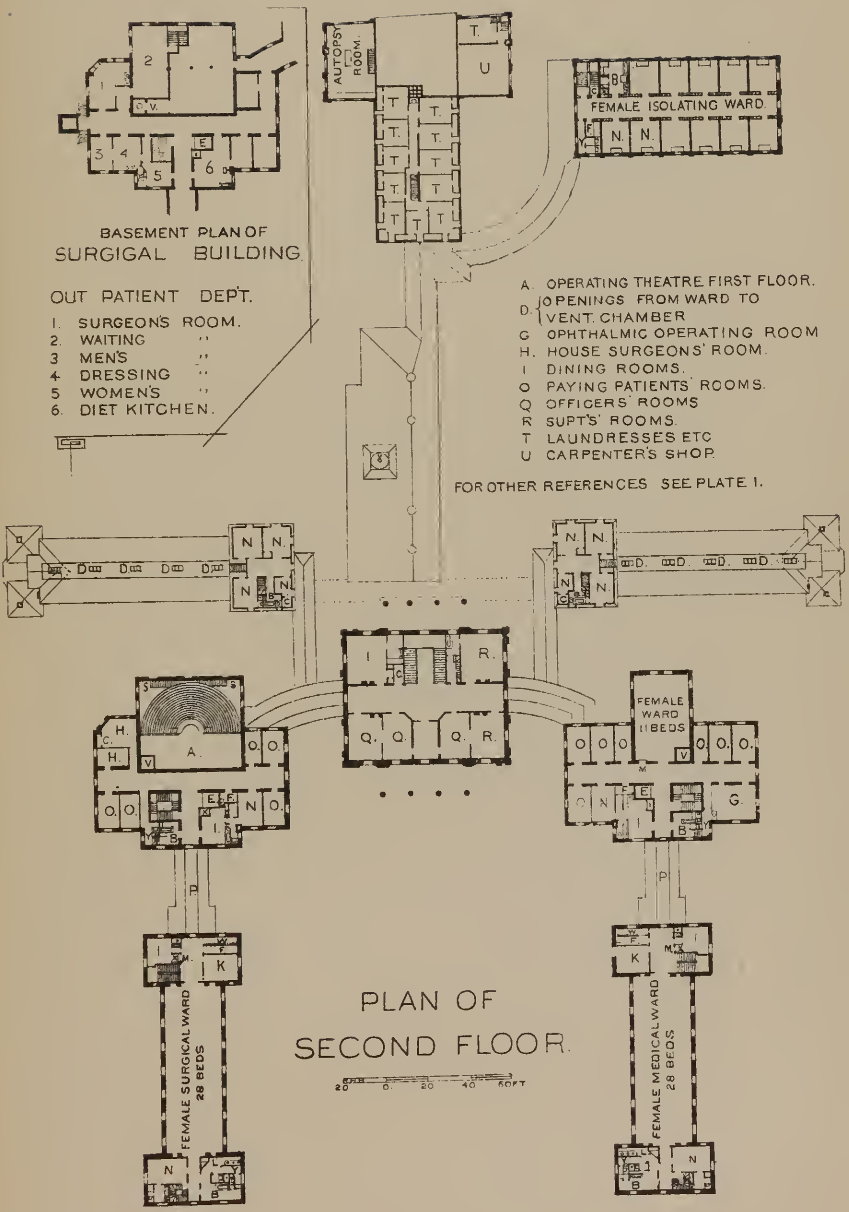

BASEMENT PLAN OF
SURGICAL BUILDING.
OUT PATIENT DEPT.
1. SURGEON'S ROOM.
2. WAITING "
3 MEN'S "
4 DRESSING "
5 WOMEN'S "
6. DIET KITCHEN.
AUTOPSY ROOM.
FEMALE ISOLATING WARD.
A. OPERATING THEATRE FIRST FLOOR.
D. {OPENINGS FROM WARD TO VENT. CHAMBER
G OPHTHALMIC OPERATING ROOM
H. HOUSE SURGEONS' ROOM.
I DINING ROOMS.
O PAYING PATIENTS' ROOMS.
Q OFFICERS' ROOMS
R SUPT'S' ROOMS.
T LAUNDRESSES ETC
U CARPENTER'S SHOP.
FOR OTHER REFERENCES SEE PLATE 1.
FEMALE WARD 11 BEDS
FEMALE SURGICAL WARD 28 BEDS
FEMALE MEDICAL WARD 28 BEDS
PLAN OF
SECOND FLOOR.
20 0 20 40 60 FT

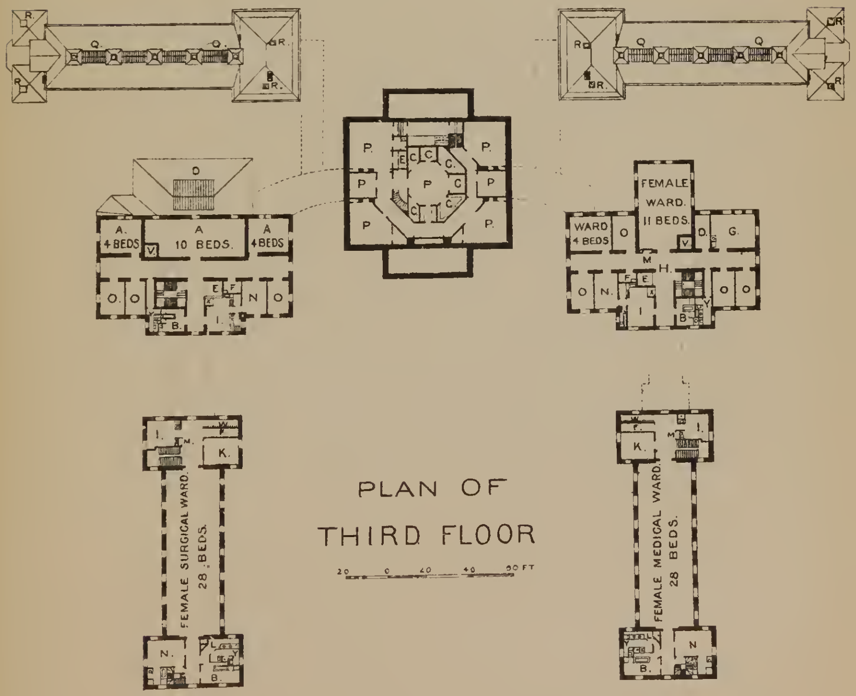
PLATE Nº 3.

KITCHEN. BAKERY AND STORE ROOMS.

10 0 10 20 30 40 50.
SCALE OF FEET

A CHILDREN'S WARDS.
D SKYLIGHT OVER OPERATING THEATRE.
G OPERATING ROOM
H WARDS AND ROOMS FOR DISEASES OF WOMEN.
O PAYING PATIENTS' ROOM.
P CHAMBERS.
Q GLAZED ROOF OF VENT. CHAMBER
R VENTILATORS.

FOR OTHER REFERENCES SEE PLATE Nº I



PLAN OF
THIRD FLOOR

20 0 20 40 60 FT

work occupies the time between seven and ten A.M., at which time morning samples were taken. This general disturbance of the morning distributes the organisms throughout the air, where we find them in increased numbers; while in the afternoon a sufficient time has elapsed for many of them to settle out again.

III. — In the afternoon micro-organisms are most abundant in the upper wards, H and D, of each pavilion.

Ward H in the medical and D in the surgical pavilion are seen to be higher in micro-organisms in the afternoon than the other wards. There are two reasons for this: First, cubic space; second, unusual disturbance by patients. The cubic space per bed for the lower ward is 1,265 cubic feet; for the upper ward, 790 cubic feet. This comes from the difference in height, — 16 feet for the lower wards, against 10 feet for the upper wards. The unusual disturbance alluded to in these wards consists in a greater amount of walking about. There are fewer helpless cases, and consequently a larger proportion are up and about the wards. So much movement in a ward keeps the micro-organisms more completely in suspension, so that large numbers are more uniformly found throughout the afternoon than in more quiet wards with greater cubic space.

IV. — Female wards C and G contain less micro-organisms than the male wards.

There is far less commotion in a female than in a male ward, women being much more quiet than men. Such patients as are able to be up, remain, as a rule, sitting quietly by their bedsides, so that the fewer number of micro-organisms in the air of a female ward is quite what we should expect.

Medical and Surgical Pavilions, Nos. 1 and 2.

The next buildings to be considered, taking them in order of plan (plate No. I.), are the medical and surgical buildings, numbered 1 and 2. Their general dimensions are 24 feet by 94 feet, the height being the same as those just described. A projection from the rear wall of the medical pavilion gives a

small ward of eleven beds on each floor, the remaining space being divided into rooms of various sizes, opening from a central corridor, and devoted principally to paying patients, both male and female. The open wards are devoted exclusively to women, the lower ward being for convalescent patients. The lower ward, M, of the surgical pavilion, contains the operating amphitheatre and the accident rooms, and is entirely devoted to the demands of operative surgery. The middle floor, ward N, is exclusively a private ward, for both men and women. The upper floor, ward O, is the children's ward, and, in addition to three small wards, it has a number of private rooms for adults.

Owing to the distribution of floor space, and the purposes to which these buildings are devoted, the results obtained in them are not comparable with those in the two buildings just described. The wards (Q, R, S) on each floor of the medical building correspond closely with each other, but not with the wards (M, N, O) of the surgical building.

Below are the tables of averages for each ward, all results being the mean of five determinations. Morning samples were taken between ten and eleven A.M.; afternoon samples, between two and four P.M.

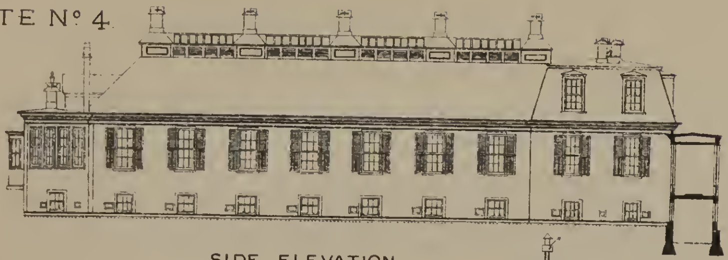
Medical Pavilion.

Afternoons, November, 1888.				Forenoons, December, 1888.			
	Female Wards.				Female Wards.		
	Q.	R.	S.		Q.	R.	S.
Bacteria, . .	8.6	9.8	8.8	Bacteria, . .	9.6	13.5	5.4
Moulds, . .	8.2	9.8	13.0	Moulds, . .	7.4	9.8	19.6

Surgical Pavilion.

Afternoons, November, 1888.				Forenoons, December, 1888.			
	Wards.				Wards.		
	M.	N.	O.		M.	N.	O.
Bacteria, . .	13.3	2.5	13.5	Bacteria, . .	14.6	18.2	15.3
Moulds, . .	9.3	11.0	19.0	Moulds, . .	15.0	7.0	26.5

PLATE Nº 4.



SIDE ELEVATION
FIG. I.

FIG. 2 REAR.

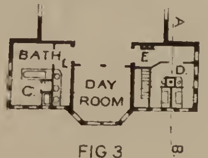


FIG 3

PLAN OF BATH ROOM AND W.CLOSETS.

10. 0. 10 20. 30.FT

C. SITZ BATH. STEAM BATH. SHOWER BATH.
D. VENT SHAFT. SLOP SINK. URINAL.
E. LOBBY.

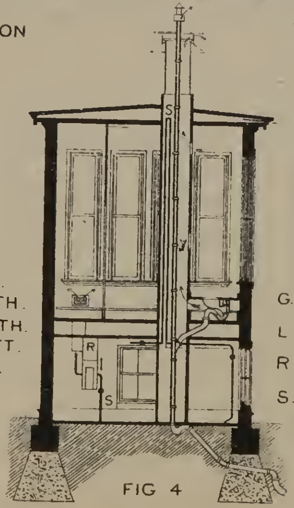
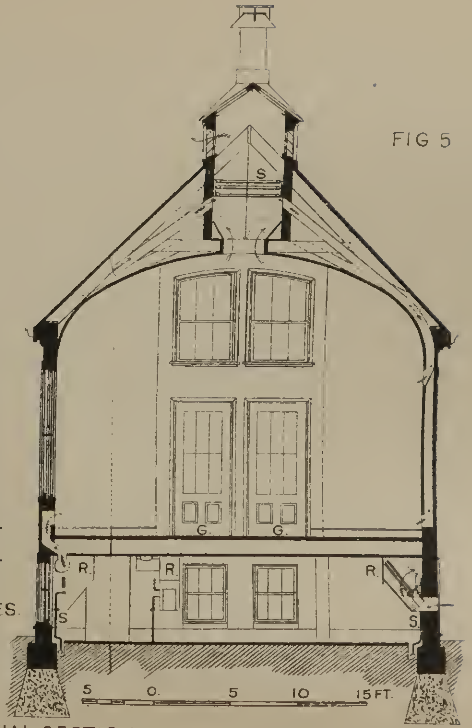


FIG 4

SECTION ON LINE A B
VENT. OF W. CLOSETS

G. DOORS TO DAY ROOM.
L LAVATORY.
R CASING OF RADIATOR.
S. STEAM PIPES.

FIG 5



PARTIAL SECTION THROUGH WINDOW.

PARTIAL TRANSVERSE SECTION BETWEEN WINDOWS.

DETAIL OF HEATING AND VENTILATING.

These tables do not show the striking differences seen in the larger medical and surgical buildings.

Medical Pavilion. — In this building the numbers found are very small, and are practically alike for bacteria and moulds. The determinations made in the morning do not materially differ from those made in the afternoon. The finding of small numbers of micro-organisms in the air of a ward during the forenoon is the best proof we can have of the absence of germs from the room itself.

Surgical Pavilion. — In the afternoon the wards of the surgical building agree in the number of bacteria found, excepting in ward N. Ward O was more abundant in moulds, both forenoon and afternoon, than the other wards; and this is true of ward S, the corresponding ward of the medical building. During the month of November, ward N was closed, and the samples were all taken with the ward empty, and very quiet. The average number of bacteria found at this time was 2.5 per 10 litres of air; but in December, with two patients and one nurse present, the number of bacteria was 18.2.

One-story Medical and Surgical Pavilions, Wards T and P.

The one-story buildings are shown in plan in plate No. I., where they are numbered 3 and 4; and a section and elevation of the surgical pavilion are shown in plate No. IV. The two buildings are alike in form and arrangement. The ward is 94 feet long, by 26½ feet wide, and has seven opposite windows and fourteen beds on a side; the windows, having double sashes, are 9 feet high by 4 feet wide. The height of the ward, from the floor to the centre of the arched ceiling, is 22 feet, or an average of about 19 feet. The floor area for each bed is 89 square feet, and the air space about 1,700 cubic feet. The basement is an open and free air space, containing only heating apparatus. The floor is made hard and impenetrable to moisture by concrete and cement, and is on a level with the ground outside. Its numerous windows can be left open many months in the year; and, its doors being locked, it is cleanly and free from any intrusion.

The method of heating and ventilating these buildings is

shown in plate No. IV., fig. 5. The air enters the ward only through inlets under each window, fourteen in all. The foul air escapes through five large openings along the centre of the arched ceiling, each 3 feet by 6 feet, into a ridge chamber, and thence either through the free openings in the sides of the chamber above the roof, or through five ventilators, each 2 feet in diameter, on the top of the ridge.

It has been found, by air-meter tests, that the whole volume of air in the wards, about 47,600 cubic feet, or 1,700 cubic feet per patient, is changed between three and four times hourly.

A consideration of the number of micro-organisms found in these wards is particularly interesting, as they represent the modern ideas of hospital construction. The system of heating and ventilation is regarded as excellent, and they are considered model wards, in all respects. The following table shows the average number of micro-organisms found in both wards, forenoon and afternoon: —

Ward P (Surgical, Male). Samples taken Afternoons, November. 1888.

Date.	Time.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	Remarks.
Nov. 3,	4.25	69	27	23	12	Some walking about.
" 9,	3.10	70	28	25	35	Close smell.
" 15,	2.10	70	-	9	2	Fifteen visitors present.
" 20,	-	64	25	12	15	Twenty-two visitors present; ward quiet.
" 30,	3.00	65	31	12	6	Considerable walking about.
Average, ...				16.2	14	

Ward P (Surgical, Male). Samples taken Mornings, December, 1888.

Dec. 3,	11.00	70	31	6	0	Ward quiet.
" 7,	10.45	66	28	21	7	Surgeon's visit, with fourteen students.
" 24,	11.15	72	25	5	14	Ward quiet.
Average, ...				10.6	7	

Ward T (Medical, Male). Samples taken Afternoons, November, 1888.

DATE.	Time.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	REMARKS.
Nov. 3,	4.15	68	27	13	0	Windows closed.
" 9,	3.00	70	25	11	20	End door open; some walking about.
" 15,	2.30	70	–	9	4	Fourteen visitors present; ward quiet.
" 20,	3.00	65	16	6	7	Sixteen visitors present.
" 30,	2.40	63	25	19	7	Changed some bedding.
Average,				11.6	7.6	

Ward T (Medical, Male). Samples taken Mornings, December, 1888. and January, 1889.

DATE.	Time.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	REMARKS.
Dec. 8,	11.15	69	25	22	9	Mopping floor.
" 13,	11.25	64	26	29	4	Ward quiet.
" 24,	11.10	68	24	8	1	Mopping floor.
Jan. 2,	–	–	–	26	15	
Average,				21.3	9.5	

No high numbers appear in any of the determinations, either forenoon or afternoon. In ward T the bacteria found in the forenoon are about twice the number found in the afternoon, while the moulds are about the same. In ward P, on the contrary, both bacteria and moulds are highest in the afternoon. This is perhaps due to the fact that the determinations that were made in the morning occurred too late to be affected by the general disturbance of ward work.

During the morning of December 7, ward P was visited by the surgeon and fourteen students, all moving about from bed to bed. The number of bacteria found was but 21. Again, on the four afternoons when visitors were present, in both wards P and T, the number of bacteria was less than it was on other days. With wards in good order, it seems to be true for all, that the presence of visitors does not as a rule increase the number of micro-organisms. The large cubic

space, excellent ventilation, and perfect cleanliness of these buildings, is sufficient to account for their freedom from micro-organisms.

Isolating Wards, K and L.

A two-story brick building, located near the southern corner of the grounds, contains the male and female isolating wards, which are shown in plates I. and II. The building is $101\frac{1}{2}$ feet long, and $46\frac{1}{2}$ feet wide, with a basement or cellar underneath, which brings the first floor to a height of about two feet above the ground level. There is a ventilating chamber on the roof, 10 feet wide, extending the whole length of the building. A hall or passage way, 10 feet wide, divides each story, with rooms on either side, and windows at each end, excepting at the entrance door on the first floor. There are ten rooms on each floor, 14 feet by 15 feet in size, and designed to accommodate from one to four patients in each. The rooms on the first floor, for male patients, are 14 feet high; and those on the second floor, for females, are 18 feet high. The fresh-air supply is admitted through openings in the outer wall under the windows, and near the floor in each. A steam radiator is placed in front of these openings, and surrounded by a casing of wood lined with tin, having a register in front. A simple arrangement of sliding valves within the casing controls the temperature and volume of the entering air. The air of these rooms is believed to be changed from three to four times hourly.

The service of these wards is the most arduous of any connected with the hospital. For many years they furnished the only available place for the treatment of contagious diseases, as well as a class of cases which, by reason of uncleanliness, delirium, etc., were not fit to remain in an open ward. During the summer of 1888 they were vacated, and thoroughly renovated. The opening of the new wards for contagious diseases has removed the necessity of treating such cases here. At present there are treated in these wards, alcoholismus, alcoholic pneumonia, erysipelas, rheumatism, typhoid fever, and many unclean medical and surgical cases.

The above facts are mentioned because it was thought that these wards would furnish a larger number of micro-organisms than other parts of the hospital.

Of the tables of determinations representing the work done in this building, the following show the average results for morning and afternoon, in the corridor of each ward; while the others show the condition of the rooms themselves. All determinations made in the rooms of each ward were made on the same day, each determination following the other in succession. The number of micro-organisms found in ward K corridor in the afternoon is surprisingly small; and even in the morning, when there was considerable walking about by nurses and patients, the numbers found were also small. Moulds appear from the table to abound in ward L. The bacteria were few in number both forenoon and afternoon.

Ward K (Male), Isolating Ward. Samples taken Afternoons.

Date.	Time.	Temperature, Degrees.	Bacteria.	Moulds.	Remarks.
Nov. 2,	-	71	3	6	End door and window open; considerable draught; floor unclean; some walking about.
" 10,	2.25	66	11	5	End window open; draught; considerable walking about.
" 16,	2.50	68	0	17	End door and window open; considerable draught.
" 21,	3.00	65	1	4	End window open; some walking about.
Average, . . .			3.6	6.2	

Ward K (Male,) Isolating Ward. Samples taken Mornings.

Date.	Time.	Temperature, Degrees.	Bacteria.	Moulds.	Remarks.
Dec. 1,	12.00	59	10	8	Corridor door open; cool draught; patients walking about; floor unclean.
" 11,	11.30	64	13	28	End door and window open; draught; some walking about.
" 17,	10.25	66	7	1	End door and window open; considerable walking about.
" 26,	12.00	64	18	6	Floor just previously swept; end door and window open.
Average, . . .			12	10.8	

Ward L (Female), Isolating Ward. Samples taken Afternoons.

Date.	Time.	Temperature, Degrees.	Bacteria.	Moulds.	Remarks.
Nov. 2,	-	72	10	8	End window open; considerable draught.
" 10,	2.10	67	23	8	Visitors' day; ward previously swept.
" 16,	2.35	70	5	67	End window open a little; windows in room open.
" 21,	2.45	63	2	13	End window open; cool draught.
Average, . . .			10	24	

Ward L (Female), Isolating Ward. Samples taken Mornings.

Date.	Time.	Temperature, Degrees.	Bacteria.	Moulds.	Remarks.
Dec. 11,	11.15	6[illegible]	4	99	Pretty quiet; some walking about.
" 17,	10.40	–	5	12	Quiet.
" 26,	12.[illegible]0	–	19	11	End window open; quiet.
Average, . . .			9.3	40.7	

Patients' Rooms. — As before stated, these rooms are 14 feet by 15 feet, with a cubic space in ward K of 2,940 cubic feet, and in ward L, 3,780 cubic feet. With two or three patients in a room, the cubic space is ample; but in ward K, with four patients in a room, which the demands upon the ward frequently necessitate, the cubic space is rather small.

The following tables show the results of one determination in each room, the rooms being numbered from 1 to 12 in each ward: —

Ward K (Male), Medical and Surgical. (February 4.)

Time.	Room.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	Remarks.
10.30 A.M.	1	86	4	6	2	Strong draught.
2.05 P.M.	2	75	2	10	7	Porter's room; strong draught; 2 occupants; 1 asleep.
10.45 A.M.	3	82	1	15	6	Strong draught.
1.50 P.M.	4	28	4	11	9	Three medical; 1 surgical; swept 1¾ hours before; slight warm draught.
11.00 A.M.	5	74	3	37	3	Three medical; strong draught; 2 patients up; bad odor.
1.30 P.M.	6	73	4	22	6	Four surgical patients; swept 1½ hours before; transfer made and erysipelas patient brought in.

Ward K (Male), Medical and Surgical. (February 4.) — Concluded.

Time.	Room.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	Remarks.
11.10 A.M.	7	61	–	9	6	Strong draught; no patients.
1.15 P.M.	8	75	4	18	1	Two medical; 2 surgical; strong draught; swept 1 hour before; 2 patients up.
12.45 "	9	70	4	11	4	Four surgical; slight draught; 1 patient up; swept after dinner.
1.00 "	10	72	4	–	–	Three surgical; 1 medical; draught strong; swept 3¼ hours before; 2 patients up.
1.25 "	11	79	6	15	5	Private room; cool draught through radiator.
2.40 "	12	65	–	11	4	Kitchen.
Average, ...				15	4.4	
Open air, ...				3	2	

Ward L (Female), Medical and Surgical. (February 4.)

Time.	Room.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	Remarks.
10.20 A.M.	1	70	3	4	9	All medical; 2 patients up; quiet; slight draught.
10.40 "	3	72	4	–	–	
10.55 "	4	72	3	0	9	All medical; quiet; slight warm draught.
11.05 "	5	72	3	3	7	All medical; quiet; strong warm draught.
1.15 P.M.	6	72	4	3	7	Two medical; 2 surgical; swept 1 hour before; 1 patient up; strong draught.
1.45 "	7	69	3	10	10	All medical; swept 1½ hours previous; strong draught; quiet; floor not clean.
1.30 "	8	72	3	10	11	Bad smell; swept 1 hour previous; strong draught; floor not clean.
2.00 "	9	69	2	6	3	One medical; 1 surgical; swept 1½ hours previous; floor clean.
2.15 "	10	72	4	14	5	One medical; 3 surgical; floor swept 1 hour previous; strong draught.
2.30 "	11	68	2	–	–	Floor swept 2 hours previous; 1 medical; 1 surgical.
2.45 "	12	68	2	4	17	One medical; 1 surgical; quiet; floor swept 2 hours previous.
Average, ...				5	8.7	
Open air, 9.55 A.M. . .				19	3	

These tables show a most excellent condition of the air of these rooms as regards micro-organisms. The number of bacteria found in ward K, although three times as many as in ward L, compares favorably with other parts of the hospital. The writer is of the opinion that the differences between wards K and L are more apparent than real, and that more organisms are present in the rooms in ward L than the determinations of air indicate, although perhaps not so many as in ward K. No other wards of the hospital furnish similar rooms for comparison; but the rooms of certain employees (women) on the third floor of the administration building (see table, p. 190) are not unlike them, in that they contain from two to four beds. Here were found an average of 20 bacteria against 15 for the rooms in ward K, and 5 for rooms in ward L. There was nothing in the condition of the rooms that would indicate whether the numbers of micro-organisms would be high or low. Most of the windows were closed, but the doors opening into the corridor were open. A strong draught of warm air came from the radiator, indicating an abundance of fresh air. In room 5, ward K, giving the highest number of bacteria, a disagreeable odor was noticed; but this was the only room where any offensive odor was detected. These rooms certainly show a freedom from micro-organisms scarcely to be expected from the class of cases assigned to them.

Contagious Wards, A and E.

The two new wards for infectious diseases are practically alike. They occupy the space shown in plate No. I., between the isolating wards and the medical ward numbered 4. They are connected with each other and the rest of the hospital group by two-story corridors, the upper story being open and the lower one enclosed.

Each building may be considered as divided into five sections. The centre section contains the service rooms; on either side is an open ward, and in the end sections are placed the isolating rooms. A second story over each end section furnishes room for more complete isolation of patients, when necessary. The open wards are 25 feet 8 inches, by 35 feet 4 inches, and are 16 feet high; giv-

ing to each bed, eight in number, 1,200 cubic feet of air.

In the centre of each ward is a square ventilating shaft, 5 feet by 4 feet, and on two sides are fireplaces. None of the basement rooms are intended for occupancy. The space under the wards has concrete floors, and is whitewashed. Air is admitted by direct inlets, placed at proper intervals in the basement walls, and by means of a diaphragm may be made to pass over coils in galvanized iron boxes, or may pass directly to the wards without going over the coils. The system will supply 48,000 cubic feet of warm air per hour, or 6,000 cubic feet per patient. The upper portions of the wards are ventilated through register faces in the walls and ceilings, and thence upwards to a ventilating ridge chamber. The lower portions of the ward are ventilated downwards through registers in the floors, and thence to the aspirating shaft in the centre of each ward. The capacity of each ward is 24 beds, or, including the chambers, a total capacity for both wards of 72 beds. Ward A is devoted to the treatment of scarlet-fever, ward E to diphtheria.

Contagious Wards.

Ward A (Scarlet-fever). Samples taken Afternoons, November, 1888.

Date.	Time.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	Remarks.
Nov. 10,	–	72	4	1	2	Sample taken in A, North. Ward quiet.
" 15,	–	73	7	12	2	Sample taken in A, South. Three visitors present. Ward quiet.
" 21,	–	64	7	0	2	Sample taken in A, North. Ward quiet.
Average, ...				4.2	2	

Ward E (Diphtheria). Samples taken Afternoons, November, 1888.

Nov. 1,	3.00 P.M.	73	5	4	5	Sample taken in E, South.
" 10,	2.15 "	72	4	7	6	Sample taken in E, North. Ward quiet.
" 15,	2.45 "	73	7	17	0	Sample taken in E, South. Three visitors. Nurse caring for patients. Ward quiet.
" 21,	3.15 "	74	7	1	5	
Average, ...				7.1	4	

Ward E (Diphtheria). Samples taken Mornings, December, 1888.

Date.	Time.	Temperature, Degrees.	Number of Patients.	Bacteria.	Moulds.	Remarks.
Dec. 1,	12.00 A.M.	68	4	0	7	Sample taken in E, South. End window open.
" 5,	11.35 "	69	6	0	0	Sample taken in E, North. Ward quiet.
" 10,	11.35 "	74	7	4	7	Sample taken in E, South. One visitor.
" 14,	10.35 "	65	–	8	4	Sample taken in E, North. Making beds.
" 26,	11.40 "	–	6	5	17	
Average, ...				5.8	6.4	

The above tables, representing the determinations made in the contagious wards, show a freedom from micro-organisms not to be found in any other wards of the hospital, the nearest approach to them being the three female medical wards, Q, R and S (see table, p. 174).

These buildings, being divided into sections, although communicating, furnish wards about the size of Q, R and S, but with fewer beds; and the results obtained in wards of this character show that they are less likely to become contaminated with micro-organisms than the larger wards.

All the conditions which are unfavorable to a vitiated atmosphere, except the patients themselves, are found in these wards. The buildings are new, sanitary conditions perfect, ventilation good, cubic space large, great cleanliness of rooms and furniture, and an intelligent and abundant use of disinfectants. Nevertheless, in spite of the greatest precautions, the opportunity of infectious material being set free in the room exists in the treatment and care of patients. Diphtheritic patients especially receive a vast amount of spraying, douching and painting of throats. Discharges from the mouth and nose are very profuse, and offensive in odor. Cloths, bits of rag and feathers are used in removing such discharges; but, with all precautions, bedding and clothing of patients, especially children, must become more or less contaminated, and from these infectious material is transmitted to the air.

The duties of the nurses in these wards are very laborious;

but, the separate wards being small, the work is carried out in a quiet manner, and the commotion of the larger wards is never seen in them.

Up to the present point, it has been the object of this paper to show the number and distribution of micro-organisms in the wards of the hospital; it now remains to consider some other facts brought out by these experiments. It has been shown that the micro-organisms present in the air of a room in the forenoon exceed those found in the afternoon, and that this is due to the disturbances which always occur in the morning. We should therefore think of them as associated with the room itself, rather than with the air; for the air of a room, if left undisturbed, soon becomes practically free from organisms. That there are micro-organisms at all in the air of rooms, depends upon whether they are occupied or not, or upon the degree of commotion in them. With a view to finding out how nearly the air of the wards became free from micro-organisms under the most favorable conditions, the following experiments were carried out between eleven and twelve o'clock at night: —

Night Work.

Date.	Ward.	Time.	Bacteria.	Moulds.
Dec. 27, ...	B	11.20 P.M.	1	4
" 27, ...	C	11.45 "	2	1
" 27, ...	D	12.10 A.M.	0	2
" 28, ...	F	11.15 P.M.	1	0
" 28, ...	G	11.35 "	0	1
" 28, ...	H	11.52 "	13	3

Between seven and eight o'clock P.M. helpless patients are made comfortable for the night, others prepare for bed, and at eight o'clock the lights are turned out. One person is on duty in each ward during the night. Usually a few very sick patients require attention; but, with this exception, the wards remain quiet until morning.

It will be noticed, from the table of night work, that the wards in which these determinations were made are those belonging to the large three-story medical and surgical buildings, where all our greatest numbers of micro-organ-

isms were found. These experiments show conclusively that the air of a room vitiated by bacteria will in three or four hours become practically free from them, if disturbing influences are removed. The determination in ward H gave 13 bacteria and 3 moulds, — numbers nearly as large as we should obtain under ordinary conditions. Unusual results of this kind cannot be anticipated, and, as four or five days are required to complete a determination, the cause can seldom be traced. The moulds are a trifle higher than the bacteria, in numbers; which is what we should expect, for we know that moulds are relatively lighter than bacteria, and of course remain suspended longer.

Experiments Before and After Sweeping.

The following experiments were undertaken to bring out more clearly the effects of unusual disturbances in increasing the numbers of micro-organisms in the air of a ward. The greatest amount of commotion occurs between 7.30 and 9.30 A.M., and the greatest amount of dust is caused by the first sweeping of the morning. There is a good deal of dust, lint, etc., upon the floor of these large wards in the morning; and, as dust and micro-organisms go hand in hand, we should expect to find micro-organisms more abundant just after sweeping than at any other time. The following table of determinations, made just before and after sweeping, shows this to be the case: —

Date.	Ward.	Before Sweeping.		After Sweeping.	
		Bacteria.	Moulds.	Bacteria.	Moulds.
Dec. 18, ...	F	56	1	99	2
" 27, ...	B	23	3	55	26
" 27, ...	C	32	22	104	40
" 27, ...	D	31	32	30	37
" 28, ...	F	104	2	160	3
" 28, ...	G	45	2	38	15
" 28, ...	H	43	8	81	1
Jan. 2, ...	P	40	12	10	11
" 2, ...	T	26	15	24	13
" 3, ...	B	20	6	7	30
Average, ...		42	10.3	70.8	17.8

The average number of bacteria found after sweeping is seen to be nearly twice the number found before sweeping. The ratio of bacteria to moulds in these wards is in the proportion of 4 to 1, under both conditions.

The table not only shows the effect of sweeping, but the whole general effect attending the opening of a large general ward in increasing the number of micro-organisms. We have seen by the previous table of determinations, made about midnight, that the micro-organisms of a ward practically all settle out in three or four hours. It follows, then, that the air remains free from them throughout the night, and is free at the time of opening the ward. The number of bacteria present in ten litres of air at any time after midnight is one or less than one. If, then, we consider the number present at the beginning of the hospital day as one, the increase in numbers due to disturbances caused by routine work of the morning, other than sweeping, would be as 42 to 1; and, including sweeping, as 71 to 1.

Probably the greatest factor, next to sweeping, in increasing the number of micro-organisms in the air of a room, is bed-making. The hospital bed, made up, measures about 8 feet 3 inches, by 2 feet 6 inches; which gives, in a ward of 28 beds, 577 square feet of surface area, — a little more than one-fourth the total floor area. These beds, of course, cover an amount of floor space equal to their size; so that, in reality, the surface which they present to falling organisms is about one-third the whole surface exposed. In the process of bed-making, many of the organisms which have previously settled out upon the clothes are again wafted into the air, as of course would be any bacterial discharges with which the bed linen might be contaminated. I refer particularly to very slight discharges; for, in case of noticeable discharges, the soiled linen is immediately removed, with proper precautions.

Ventilating Ridges.

Each hospital building is surmounted by a ventilating ridge, into which the foul air of the ward passes, either by means of flues in the wall or through large openings along the centre of the ceiling. From thence it passes directly

to the outer air through large ventilators, placed at equal distances along the top of the ridge. These chambers extend along the roof over that portion covering each ward; they are about 5 feet wide, and of more than sufficient height to permit an upright position. The roof of each chamber is peaked, and made of glass. They can be heated by steam if necessary, but this is seldom, if ever, resorted to.

It was thought to be a question of considerable importance to determine the relation between the air of these chambers and that of the wards; for such knowledge leads directly to the important question, whether or not there is elimination of micro-organisms in a mechanically ventilated building.

Ridges designated H and D discharge the air from the large three-story medical and surgical buildings, containing wards F, G and H, and B, C and D respectively; while ridges P and T discharge for the one-story buildings, wards P and T.

Ventilating Ridges.

DATE.	Ridge Chamber.	Bacteria.	Moulds.	Bacteria in Air of Wards.	Moulds in Air of Wards.	REMARKS.
Dec. 7,	P	57	9	21	7	Strong upward draught.
" 12,	D	2	8	9	5	Ventilators drawing well; no currents felt in the chamber.
" 18,	D	2	1	10	2	Ventilators drawing well; no currents felt in the chamber.
" 19,	H	3	1	106	6	Ventilators drawing well.
" 24,	T	1,149	0	8	1	Good upward currents from ward below; not much from wall outlets.
" 24,	P	6	5	5	14	Good upward currents from ward below; not much from wall outlets.
" 27,	D	6	22	31	32	Ventilators drawing gently.
" 28,	H	17	7	81	1	Ventilators drawing well.
Jan. 2,	T	12	3	26	15	Strong draught from ward below; slight from wall outlets.
" 2,	P	4	10	40	12	Strong draught from ward below; slight from wall outlets.

The tables give, in addition to the micro-organisms found in the air of the ventilating chambers, the number of bacteria and moulds in the air of the wards just beneath, about fifteen minutes before. The table shows, for the most part, extremely small numbers of micro-organisms, — so small as to

lead at once to the conclusion that the air, in passing from the wards below, does not carry with it micro-organisms to any considerable extent.

It is safe to say that, in wards without special means of air outlets, and with only ordinary means of ventilation, micro-organisms do not escape; but in wards like P and T, with exceptionally good ventilation, they do escape, and the total number in the ward is thereby much diminished.

From the fact that micro-organisms settle out so rapidly, probably floor ventilation, such as exists in the contagious wards, aids materially in the elimination of micro-organisms; but the most efficient means for ordinary rooms, after sweeping or any unusual disturbance, is a good current of outdoor air, by means of open windows and doors.

Administration and Other Buildings.

So far as I am aware, no standard has been proposed for the number of micro-organisms habitually present in the air of hospital wards. The terms large and small, as applied to the number of organisms found in this investigation, have therefore been used entirely in a relative sense. The determinations that have been made upon outside air, while useful as a comparison, cannot properly be taken as a standard of the purity of the air of rooms; for individual experiments made on outside air and the air of wards at about the same time show no relation whatever, and it is quite possible for rooms of the better class to contain far less organisms than outside air. In the absence, then, of a proper standard of purity for hospital air, it seemed to the writer that an investigation of the air of certain hospital buildings not occupied by the sick would afford a useful means of comparison. With this object in view, the air of the following buildings was examined: —

First. — Administration building.

Second. — Nurses' home.

Third. — Laundry, with rooms of the laundry employees.

Administration Building.

The number of micro-organisms found in various places on each floor of the administration building is shown by the following table: —

ADMINISTRATION BUILDING.

First Floor.

Place of Experiment.	Date.	Bacteria.	Moulds.
Reception-room,	Jan. 5,	64	2
Hall,	" 5,	48	6
Dining-room,	" 5,	18	7
Private office,	" 5,	12	2
Average,		35.5	4.3
Second Floor.			
Sleeping-room,	Jan. 5,	1	1
Library,	" 5,	1	2
Parlor,	" 5,	5	5
Hall,	" 5,	1	7
Sleeping-room,	" 5,	2	5
Average,		2	4
Third Floor. — Domestics' Rooms.			
Room 1,	Jan. 12,	3	5
" 3,	" 12,	28	0
" 4,	" 12,	37	4
" 5,	" 5,	34	20
" 6,	" 5,	14	8
" 7,	" 5,	5	9
Average,		20 3	9.7

First Floor. — This floor (plate I.) contains, besides a spacious hall, the superintendent's office, matron's room, family dining-room, and a large reception-room. This, being the executive department, is visited each day by many hundred people, representing all classes of society. Such is the neatness and the order of this floor, however, that no

indication is ever seen of the immense amount of business transacted. The largest number of bacteria was found in the reception-room and hall, where the greatest amount of activity exists. In the dining-room and office the numbers were much less. That bacteria are here present in the numbers found in the reception-room and hall, shows plainly how these organisms are transported by people coming from outside air into a room, by dirt on their feet and clothing.

Second Floor. — A plan of this floor is shown by plate II. Here are the living-rooms of the superintendent and a few of his officers. It corresponds to a private house of the first class. The table of data shows the air of this floor to be almost free from bacteria, as might be expected from the cleanliness and quiet which prevail.

Third Floor. — The third floor (plate III.) is divided into chambers for the use of domestics; the rooms are small, low studded, and the ventilation is poor, being only by transom windows. Consequently, a larger number of bacteria is found in the air of these rooms. The rooms are vacant most of the day, and were vacant at the time of the experiment.

Nurses' Home.

This building differs from any that has been considered; it is new, outside the hospital grounds, and is reached by a short walk in the open air. It is four stories in height, each floor having a central corridor extending its whole length, from which nurses' rooms open on either side. It is essentially what its name implies, — "a nurses' home," where quiet and comfort are found by the nurses after their duties at the hospital are over. The nurses leave the building at about 6.30 A.M., and return for the night at 8 P.M. The samples of air were all taken at about the centre of each corridor. The table below shows for the air of this building very small numbers of bacteria. Even in the morning, with housework going on, the average number of only nine bacteria were found; while in the evening, after so many nurses, fifty or sixty, had entered the building, and distributed themselves throughout its various parts, the air showed an average of but three bacteria. These results show that bacteria are not transported from the hospital wards to the

"home," at least in any appreciable numbers, and that they are not accumulated by any cause.

The very moderate number of bacteria found in this building is evidence enough that the air of even a large building may be kept comparatively free from bacteria, under proper hygienic conditions. It is noticeable that the number of bacteria found is less than we should expect to find by the same number of determinations on outside air.

NURSES' HOME.

Samples taken Jan. 4, 1889, 9 to 10 A.M.

CORRIDOR.	Bacteria.	Moulds.	REMARKS.
Basement, .	7	20	Strong draught.
First floor, .	18	59	Before sweeping; floor dirty.
Second floor, .	3	7	Very quiet; floor clean.
Third floor, .	10	11	Floor partly swept.
Fourth floor, .	9	16	Sweeping finished before experiment.
Average, .	9.4	22.6	

Samples taken Jan. 4, 1889, 8 to 9 P.M.

CORRIDOR.	Bacteria.	Moulds.	REMARKS.
Basement, .	0	20	Very hot; no one present.
First floor, .	2	4	Quiet.
Second floor, .	3	8	Very little walking.
Third floor, .	5	17	Very quiet; some draught.
Fourth floor, .	7	16	Very quiet.
Average, .	3.4	13	

Laundry.

In this building we have a wash-room and an ironing-room on the first floor, and the sleeping-rooms of the laundresses on the second floor. Every morning the soiled ward linen is taken to the wash-room, and assorted into special lots preparatory to washing. The handling of such a large amount of soiled ward linen should be a prolific source of air infection in this room; but, as will be seen from the table of determinations, the number of bacteria, although large, is not extraordinary. The day, however, on which the samples were taken, was very windy; and, the door being open, a very strong current of air was blowing through, which may have carried off a large number of

micro-organisms. Still, a larger number of bacteria was present in the wash-room than in the ironing-room, which connects directly by an open door. The rinse-house is a small out-building, in which the preliminary cleansing is given to especially foul clothing. Here, again, a pretty large number of bacteria was found, in the presence of very free air currents.

Up a narrow staircase one passes to a corridor out of which lead the laundresses' rooms. They are small, low studded, badly ventilated, but quite cleanly, owing to the strictness of the hospital rules. There is an extremely offensive odor in most of these rooms, which is attributed by the administration to the uncleanly habits of women of this class. In the morning the determinations were made after the rooms had been vacated several hours, but in the evening the women were sitting quietly in their rooms. The number of bacteria found shows undoubted evidence of vitiation of the air, due to personal uncleanliness; for the rooms themselves are clean, and it is noticeable that in the evening, with the women present, although not stirring about, the numbers increased. This is in direct contrast with the results found in the nurses' home, where, under similar conditions of experiment, the numbers found in the evening were less than in the morning.

According to the class of inhabitants, then, the number of bacteria was found to increase: for instance, in the dwelling apartments of the superintendent there was an average of 2 bacteria; in the nurses' home we have an average of 9.4 bacteria; in the domestics' sleeping apartments in the administration building were 20.3 bacteria; and worst of all the laundry employees' rooms, where there were 36.7 bacteria.

Laundry.

Place of Experiment.	Date.	Bacteria.	Moulds.
Ironing-room, ...	Jan. 7,	23	17
Rinse-house, ...	" 8,	43	5
Wash-room, ...	" 8,	33	7
Wash-room, ...	" 8,	84	6
	Average,	45.7	8.9

Rooms of Laundry Employees.

Morning.					Evening.				
Date.		Room.	Bacteria.	Moulds.	Date.		Room.	Bacteria.	Moulds.
Jan.	7,	1	38	2	Jan.	7,	1	57	1
"	7,	2	5,440*	0	"	7,	2	44	2
"	7,	3	14	2	"	7,	3	50	13
"	7,	4	27	4	"	7,	4	6	1
"	7,	5	31	2	"	7,	5	82	1
"	7,	6	40	3	"	7,	6	1	2
"	7,	7	28	1	"	7,	7	72	0
"	7,	8	18	9	"	7,	8	14	3
"	7,	9	24	10	"	7,	9	13	0
"	7,	10	33	6	"	7,	10	28	6
Average,	.		28	4.7	Average,	.		36.7	3

* Omitted from average.

Basements.

As a matter of general information, determinations of the air in the basements were made. The results are embodied in the following table: —

Date.		Basement under Ward.	Bacteria.	Moulds.	Remarks.
1888.					
Dec.	7,	P	0	101	One window on each side open; closed during experiment.
"	14,	Q	7	10	
"	17,	K	0	7	Cool and damp; strong smell.
"	18,	B	4	13	
"	19,	F	0	8	
"	24,	T	3	10	End window open; slight draught.
"	24,	P	1	36	One window open.
"	27,	B	0	69	
"	28,	F	2	3	
"	31,	Q	4	6	
1889.					
Jan.	2,	T	0	6	
Average,	. .		2	16.3	

These basements are used to some extent for the storage of furniture and other hospital property; aside from this, they serve only as open air spaces, the windows being open

in favorable weather. The walls are of solid masonry, and the floors are of concrete. Doors for the most part are kept locked, and with occasional whitewashing the basements are always clean and wholesome. It is evident from the table that bacteria do not find a congenial climate in these basements, for they are notably absent. On the other hand, moulds abound in considerable numbers; but lack of dampness and darkness keeps the numbers far below what we should find in an ordinary cellar. The presence of moulds in an atmosphere disturbed only by the leakage of air through windows, or at the most through open windows, in favorable weather, makes evident their relative lightness.

The Bacterial Examination of Air after the Fumigation of Infectious Clothing by Sulphur.

It is not within the scope of this paper to investigate the efficiency of sulphur as a fumigating agent, and no attempt has been made to do so. The experiments presented were suggested by the fact that bed-making in the wards furnished a means of air-infection. The bringing together of large quantities of bed linen for fumigation, from the infectious wards, it was thought, would vitiate the air unmistakably, and become manifest, with a few determinations of air, in the small confined space of the fumigating vault. The experiments were, however, extended, so that in reality they became a measure, not of the efficacy of sulphur as a fumigating agent, but of the method of fumigating employed in this hospital. The fumigation of infectious clothing undertakes to kill not alone the bacteria that may be present, but also the more refractory spores; and any method which fails to kill every germ and every spore, is worthless.

A description of the fumigating vault and the method of fumigation employed is as follows. The vaults are of brick masonry in the corner of a basement room, one under the contagious ward A, the other under contagious ward E. They are 16 feet long, by 9 feet wide and 9 feet high. Racks are built upon two sides, on which to deposit clothing. Tightly fitting double doors prevent the escape of sulphur fumes during fumigation, and a flue connecting with a chimney removes the fumes after fumigation is completed. All soiled

clothing from the contagious wards is sent down shutes into the basement, and on certain days of the week is removed to the vault and immediately fumigated. This is accomplished by burning in an iron pot about ten pounds of sulphur, the heat from the pot placed in a pan of water furnishing a certain amount of moisture. The exposure given is usually from six to eight hours.

In the experiments to be described, the following procedure was carried out: —

First. — A determination of the air of the room outside the fumigating vault.

Second. — A determination of the air within the fumigating vault, empty.

Third. — A determination of the air within the vault, with clothing distributed, and ready for fumigation.

Fourth. — A determination of the air within the vault, after fumigation, and in the presence of sulphur fumes.

Fifth. — A determination of the air within the vault, after the escape of the sulphur fumes.

Sixth. — A determination of the air within the vault, after the clothing had been fumigated and violently shaken.

Seventh. — A determination of the air within the vault, after the clothes had been removed.

Eighth. — A determination of the air within the vault, after a period of repose.

Ninth. — Between determinations one and eight, frequent determinations were made of the air outside the vault, as a control.

Two series of experiments were carried out, one in vault A, the other in vault E, that one might serve as a control upon the other. Of course no agreement is to be expected between the actual number of micro-organisms found in corresponding experiments of the two series, because the conditions which influence the numbers necessarily differ at different times; for example, the gross amount of clothes operated upon varies at each fumigation, the clothes themselves present different degrees of infection, and the amount of disturbance to which they are subjected will differ. Only a general agreement, therefore, must be looked for at certain critical points.

The following tables represent the results of the two series of experiments : —

Table A. Experiment 1.

Number of Determination.	Date.	Bacteria.	Moulds.	Time of Day.	Place of Experiment. — Remarks.
	1888.				
1,	Dec. 9,	0	34	9.45 A.M.	Room outside of vault.
2,	" 9,	4	19	10.09 "	Inside of vault; doors open.
3,	" 9,	0	29	10.50 "	Inside of vault; clothes on racks ready for fumigation.
4,	" 9,	3	98	11.04 "	Outside of vault.
5,	" 9,	2	13	5.50 P.M.	Outside of vault.
6,	" 9,	0	0	6.05 "	Inside of vault, in presence of sulphur fumes
7,	" 10,	3	3	8.45 A.M.	Inside of vault, after discharge of sulphur fumes; doors closed during the night.
8,	" 10,	49	28	9.00 "	Inside of vault; doors closed; clothes well shaken.
9,	" 10,	1	31	9.15 "	Outside of vault.
10,	" 10,	25	28	10.00 "	Inside of vault; clothes all out.
11,	" 10,	5	50	2.20 P.M.	Inside of vault; after repose.

Table E. Experiment 2.

Number of Determination.	Date.	Bacteria.	Moulds.	Time of Day.	Place of Experiment. — Remarks.
	1888.				
1,	Dec. 15,	36	21	9.00 A.M.	Outside of vault.
2,	" 15,	19	12	9.15 "	Inside of vault; empty.
3,	" 15,	50	11	–	Inside of vault; clothes on racks ready for fumigation.
				–	
4,	" 15,	23	13		Outside of vault.
5,	" 15,	9	4	3.45 P.M.	Outside of vault.
6,	" 15,	0	2	–	Inside of vault, in presence of sulphur fumes.
7,	" 16,	2	5	8.30 A.M.	Outside of vault
8,	" 16,	3	11	8.45 "	Inside of vault, free from sulphur fumes.
9,	" 16,	10	4	9.20 "	Inside of vault, after clothes had been shaken; doors closed.
10,	" 16,	7	16	10.10 "	Inside of vault, after removal of clothes.
11,	" 16,	3	19	11.15 "	Inside of vault, after repose.
12,	" 16,	0	7	2.00 P.M.	
13,	" 16,	0	2	4.10 "	

Description of the Tables.

The determinations to be particularly noticed are Nos. 3 and 8, in table A, and Nos. 3 and 9, in table E. Determination 3 represents the air of the vault after an enormous quantity of infectious clothes had been shaken and thrown upon the racks. Determinations 8 and 9 show the same thing, after the clothes had been fumigated for several hours. Determination 3, in table A, for some reason difficult to see, gave negative results; but determination 8 of the same table shows that the organisms were there, and retained their vitality throughout the exposure to sulphur fumes. In determination 3, table E, the numbers of bacteria were distinctly increased by handling the clothes, and the same treatment after fumigation (determination 9) still furnished some germs, although in diminished numbers. In both cases, with the vault undisturbed but filled with sulphur fumes, the result was negative, as was to be expected. The subsidence of the germs is shown in both tables, more especially in table E, where the experiments were extended with that object in view. The control experiments on the air outside the vaults show that the results obtained within the vaults were not due to causes existing without.

It was evident to the writer, that, by throwing such a large quantity of bed linen upon the racks of the vault, much of it escaped the action of the sulphur fumes; for, with doors and ventilators closed, the atmosphere is "dead," and it would be impossible for sulphur fumes to penetrate and expel the confined air between the folds of such heaps of materials. In addition to bed linen, a certain amount of infected patients' clothing, done up in "emigrant bundles," and tied up in sheets, is fumigated at each operation. A large portion of these bundles is perhaps not infected with the germs of contagion, but is filled with vermin. A careful examination of many of them outside the vault after fumigation, showed not the slightest smell of sulphur fumes beneath the outer layers. This fact suggested the following experiments. Vault E, with closed doors, was swept vigorously, racks dusted, and then subjected to fumigation in the regular

way; after which the dust was again disturbed, and a determination of the air made.

No. 1. — Before fumigation, floor swept, racks dusted, vault filled with dust. Found: bacteria, 33; moulds, 77.

No. 2. — After fumigation, sulphur fumes all out, vault quiet. Found: bacteria, 0; moulds, 1.

No. 3. — Floors swept, racks dusted, vault filled with dust. Found: bacteria, 1; moulds, 1.

The above experiments demonstrate one of the practical applications to which the bacterial determinations of air may be put. A determination of the actual efficiency of a fumigating agent must be shown by the more refined methods of bacteriological investigation; i. e., the inoculation of material with known species or their spores, subjecting the infected material to the action of the fumigating agent, and subsequent culture for negative or positive results. Conclusions are evident: whether sulphur is or is not an efficient fumigating agent, the method, as carried out here, is worthless.

In the foregoing discussion of the number of micro-organisms in the various wards of the hospital, we are left in doubt whether the averages presented represent the conditions of the air from day to day, during the two months occupied in collecting the data, or whether individual determinations are true only for the days on which they were made. Nor can we tell whether a single determination made at a given time of the morning and afternoon, as in the experiments, represents a fair average for the day itself.

Circumstances connected with a hospital ward, which may increase or decrease the number of micro-organisms in the ward itself, do not, we think, materially change from day to day. A certain standard of cleanliness is maintained, routine nursing is thoroughly systematized, the number of patients and classes of diseases vary but slightly; so that each ward becomes endowed with a character of its own, to which a pretty constant number of micro-organisms undoubtedly belong. The numbers fluctuate considerably at different periods of a single day, according to the local disturbances in the ward; which throws some doubt on single

determinations, if given to express the condition of the air other than at the time of experiment. I have endeavored to trace these variations by a series of hourly experiments, conducted throughout the hospital day.

Hourly Experiments.

These hourly experiments were made in the six wards of the two three-story buildings, in the two one-story buildings, and in one contagious ward. Hourly determinations of carbonic acid were also conducted at the same time, to see what relation, if any, exists between carbonic acid and micro-organisms in the air of these wards. The experiments were all made in the centre of the ward, at about the breathing line. In all previous work the determinations were made with the wards in the exact condition in which they were found; but in the hourly experiments it was deemed advisable to keep windows and doors closed throughout the day, thus making the wards depend entirely on the mechanical ventilation. The tables are of especial value on this account, because they represent the wards in their most unfavorable condition. All the wards are thoroughly aired in the morning by open doors and windows, and, according to the weather, are open more or less during the day. This keeps the air free from disagreeable odors, and the temperature is to some extent regulated in this way. The following sketch of daily routine work of the hospital ward is given, as upon this depends largely the variation in numbers of organisms found at different periods of the day. To this must be added a considerable amount of movement by patients.

Routine of Daily Ward Work.

7–7.30 A.M.: —

Breakfast served.

7.30–9 A.M.: —

Beds made.
Wards swept.
Pulses and temperatures taken.
Sputa cups emptied and cleaned.
Typhoid fever patients bathed and cared for.

9–9.30 A.M.: —

Bathing and caring for very sick patients continued.
Poultices made and applied.

9–9.30 A.M.: — *Concluded.*

Lotions, liniments, etc., applied.
Nutrient and cathartic enemata given.
Convalescent patients dressed.
Physicians' visit.

9 30–12 M.: —

Milk, eggnog, etc., given.
Wards dusted, floors mopped.
Physicians' visit.
Hourly medicines given.

12–2 P.M.: —

Dinner served.
Medicines given, floors swept.
Tables dusted; general care of patients.
Poultices and dressings reapplied.

2–3 P.M.: —

Milk, eggnog, etc., given.
Wednesday and Friday, general bath days.
Monday, Tuesday, Thursday and Saturday, visiting days.
Medicines given.

3–4 P.M.: —

Temperatures taken.
General care of patients.

4–8 P.M.: —

Supper served.
Poultices reapplied.
Back of patients rubbed with alcohol or starch.
Milk or other drinks given.
House physicians' visit.
Medicines given.
Changes of beds requiring it, and other preparations for the night.

One of the most interesting facts brought out by these hourly experiments is the period of high numbers due to the excessive commotion of the morning, previously alluded to. This period unmistakably begins at the time of opening the ward, about 7 A.M., and continues until the ward is in order, which varies from 9.30 to 10.30 A.M. The number of bacteria in the air varies greatly for this period, in the different wards, for of course both duration and amount of commotion are variable conditions. The object sought for by the nurses is that the chamber-work, so to speak, shall be done as soon as possible, in order that the sick may be attended to, and the ward made presentable for the morning visit of the physician or surgeon. It seems unfortunate, that, in doing this, patients should be subjected to bacteria-laden dust, which is

for a time settling on their beds and person. This stirring up of the dust could probably be diminished by sprinkling the floor with some suitable material, wet with a proper disinfectant. It is now customary, in some of the wards, to use sawdust moistened with water; but it is used so sparingly as to be of little value.

This is a question of removing mechanically the micro-organisms, not of the air, but of the room itself; and the time is never so favorable as when they are in repose on the floor and furniture. Every accumulation of a sweeping means the elimination of a certain number of organisms; and if by any means the dust which is now scattered through the air at the period mentioned could be added to that already collected by the broom, the micro-organisms present would soon be reduced to a minimum. The tables of hourly work to follow show that, at the second and third sweeping, which occurs at 12.30 P.M. and 4.30 P.M., very little dust is raised, for the number of micro-organisms in the air are only slightly increased, if at all, at those times. Of the considerable number of organisms present in the air, in the morning, many fall on the beds, some on the floor, and some remain suspended. Those which settle upon the floor are in part removed by the mopping, which always follows the first sweeping, so that very few remain to be disturbed by any cause. The point at which commotion ceases and bacteria begin to settle out is clearly shown by the tables. In the medical wards F, G, H, the drop in numbers occurs at 10.30 A.M., and is quite marked. The time varies in the surgical wards, being 9.30 A.M. in B, 10.30 A.M. in C, and 11.30 A.M. in D; while in the medical and surgical pavilions, wards T and P, it occurs still earlier, — 8.30 A.M. in both wards.

There are several periods after 9 or 10 o'clock when slightly increased numbers of bacteria might be expected: namely, at 11.30 A.M., when dinner is served, followed by a second sweeping; at 4.30 P.M., the supper hour; and again at 7.30 P.M., when the beds are arranged and patients made comfortable for the night. These occasions give rise to disturbances slightly greater than those which immediately preceded them. In wards F, H, D and T, the number of bacteria were slightly increased at the time of second sweep-

ing; but wards B, C, G and P were not so affected. The third sweeping does not appear to increase the organisms; but all the wards except F and G showed a slight increase of bacteria at 7.30 P.M., falling again when the ward was closed at 8 P.M. It appears from the hourly experiments that in general the air from about 10 o'clock assumes practically a normal condition. The figures seldom quite agree, but a certain amount of variation must always be expected in bacterial examinations of air.

The number of micro-organisms found by hourly experiments, taken as a standard, furnishes the means of demonstrating the truth of the determinations made morning and afternoon, but on different days, during November and December. In the table below, the two series are given for all wards in which hourly experiments were conducted:—

Average of Hourly Experiments, from 6.30 A.M. to 8.30 P.M., January, 1889.

	F.	G.	H.	B.	C.	D.	P.	T.	E.
Bacteria, . .	64	21	43	13	19	19	12	13	7
Moulds, . .	36	2	12	19	7	10	5	7	6

Average of One Determination, Morning and Afternoon, November and December, 1888.

Bacteria, . .	41	47	48	16	27	15	14	17	7
Moulds, . .	5	6	9	10	12	17	11	9	5

With the exception of the bacteria and the moulds in ward F, and the bacteria in ward G, the above figures, considering the manner in which the data were obtained, correspond in a manner scarcely to be expected, and strengthen the opinion previously given, that the bacteria present in the various wards are practically constant from day to day. By referring to the figures below, taken from the tables which furnish the above averages, it becomes at once evident why the two series for wards F and G do not agree.

Ward F.

Determinations Made during December.		Hourly Determinations.	
Time.	Bacteria.	Time.	Bacteria.
–	–	6.30 A.M., . . .	477
7.55 A.M., . . .	104	7.30 " . . .	106
8.55 " . . .	77	8.30 " . . .	162
10.00 " . . .	56	9.30 " . . .	51
10.30 " . . .	24	10.30 " . . .	28

Ward G.

8.20 A.M., . . .	45	8.30 A.M., . . .	59
9.10 " . . .	56	9.30 " . . .	56
10.50 " . . .	48	10.30 " . . .	15
10.35 " . . .	176		

In ward F, the determination at 6.30 A.M. gave 477 bacteria, a number considerably greater than all others throughout the day combined; and in ward G, on December 8, at 10.35 A.M., the number of bacteria was 176. Both these numbers are exceptional and accidental; they are due to what Tyndall has so aptly called "bacterial clouds." Later, such "clouds" or aggregates of bacteria are probably uniformly distributed throughout the air. By eliminating these two numbers, the average number of bacteria for ward F becomes 34, in place of 64; and for ward G, 25, in place of 47. By this change, the table of comparative results for the two series agree in every case. Although 477 bacteria for ward F, at 6.30 A.M., must be regarded as accidental, moderately high numbers are always present at this hour in the male wards, where patients are stirring about; while in the female wards bacteria are not stirred up and distributed through the air until the regular opening up of the ward.

The column on the left gives the number of bacteria found on different days at different hours; that on the right, num-

bers found in the same wards at nearly corresponding hours to the former, but on the same day. The agreement is remarkable, and shows that on any day, at a given time, the number of bacteria in the air will be about the same in these wards.

The fact that the bacteria take such a sudden drop at about 10.30 o'clock A.M., and then remain practically constant for the rest of the day, permits a sharp dividing line between bacterial determinations of the morning and afternoon; and shows that, in bacterial determinations of the air of rooms, particular attention must be given to their condition, the amount, duration and character of any disturbing influences, and the time and number of the determinations made accordingly.

The two tables below represent the hourly determinations treated in two ways: First, by making the division at 10.30 A.M.; second, by making the division at 12.30 P.M., and taking the mean of the two parts in each case. They require no special comment.

Average of Hourly Determinations, from 6.30 A.M. to 8.30 P.M.

	Wards.								
	F.	G.	H.	B.	C.	D.	P.	T.	E.
Bacteria, . .	64	21	43	13	19	19	12	13	7
Moulds, . .	36	2	12	19	7	10	5	7	6
Carbonic acid, .	7.10	6.30	8.02	–	5.53	7.05	5.68	5.72	5.62

Average of Hourly Determinations, from 6.30 A.M. to 12.30 P.M.

Bacteria, . .	121	27	56	17	16	28	20	15	8
Moulds, . .	47	1	16	19	4	11	4	3	4

Average of Hourly Determinations, from 1.30 to 8.30 P.M.

Bacteria, . .	19	15	29	9	21	10	5	3	9
Moulds, . .	21	3	7	20	9	10	5	11	9

Average of Hourly Determinations, from 6.30 to 10.30 A.M.

	Wards.								
	F.	G.	H.	B.	C.	D.	P.	T.	E.
Bacteria, . .	165	34	63	21	15	24	25	15	7
Moulds, . .	51	1	21	20	5	11	3	3	4

Average of Hourly Determinations, from 11.30 A.M. to 8.30 P.M.

Bacteria, . .	11	14	31	9	20	16	6	12	9
Moulds, . .	28	3	6	19	7	10	5	9	8

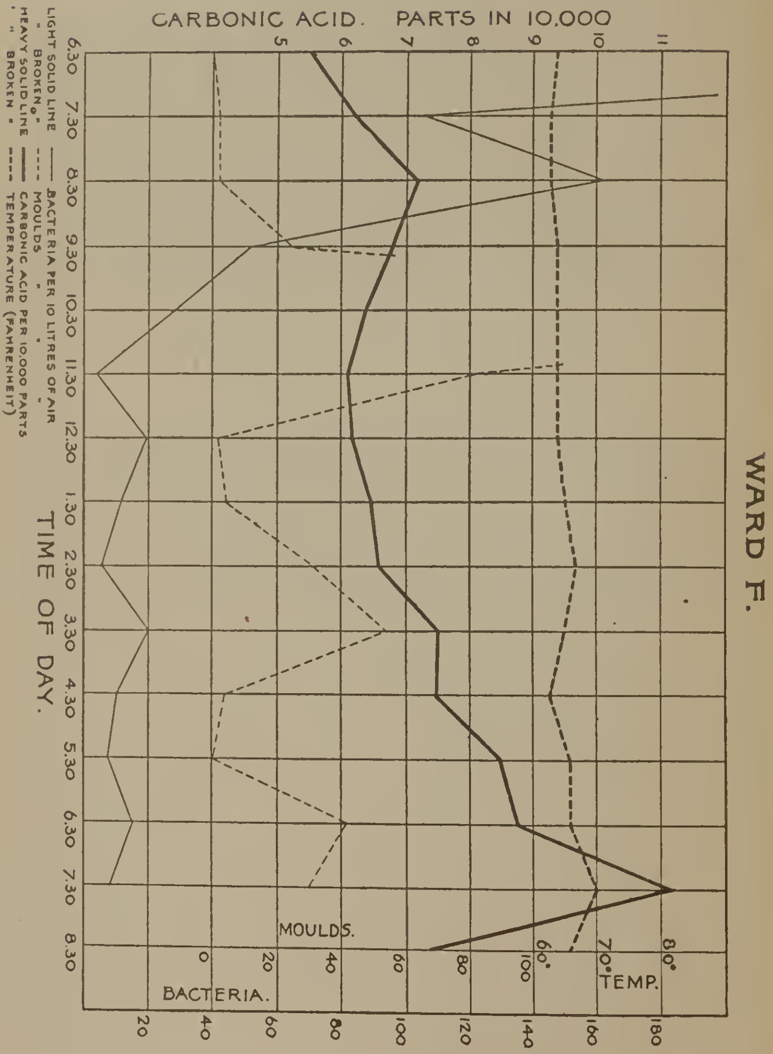
The statement previously made, that bacteria are more abundant in medical than surgical wards, is also shown to be true by hourly experiments. In the table below, the averages of hourly determinations are placed in a manner to show this, the results for each surgical ward being placed beneath the medical ward corresponding to it in situation.

Ward.	Bacteria.	Moulds.
F — Medical, ...	71	36
B — Surgical, ...	13	19
G — Medical, ...	21	2
C — Surgical, ...	19	7
H — Medical, ...	43	12
D — Surgical, ...	19	10
T — Medical, ...	13	7
P — Surgical, ...	12	5

The following tables give the full data of the hourly observations made in the various wards throughout the hospital day, from 7.30 A.M. to 8.30 P.M.

The charts were drawn from the data furnished by these tables and show graphically the fluctuation of carbonic acid, bacteria, moulds and temperature in Fahrenheit degrees from hour to hour.

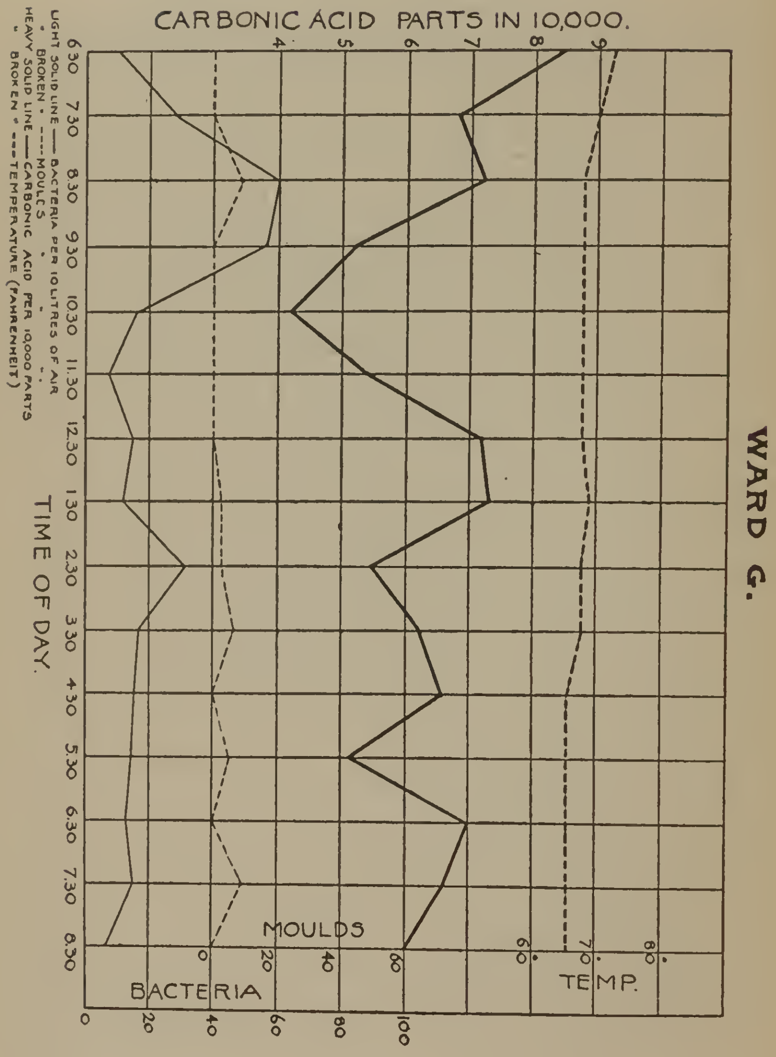
One fact shown by the charts is worthy of mention here: the proper time to mop a hospital ward is about one hour after the general sweeping; for the maximum number of bacteria appears to be reached just after sweeping and the minimum at about one hour later.


WARD F.
CARBONIC ACID. PARTS IN 10,000
TIME OF DAY.
MOULDS.
BACTERIA.
TEMP.
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR
" BROKEN " ---- MOULDS " " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10,000 PARTS
" " BROKEN " ---- TEMPERATURE (FAHRENHEIT)

Tables of Hourly Determinations.

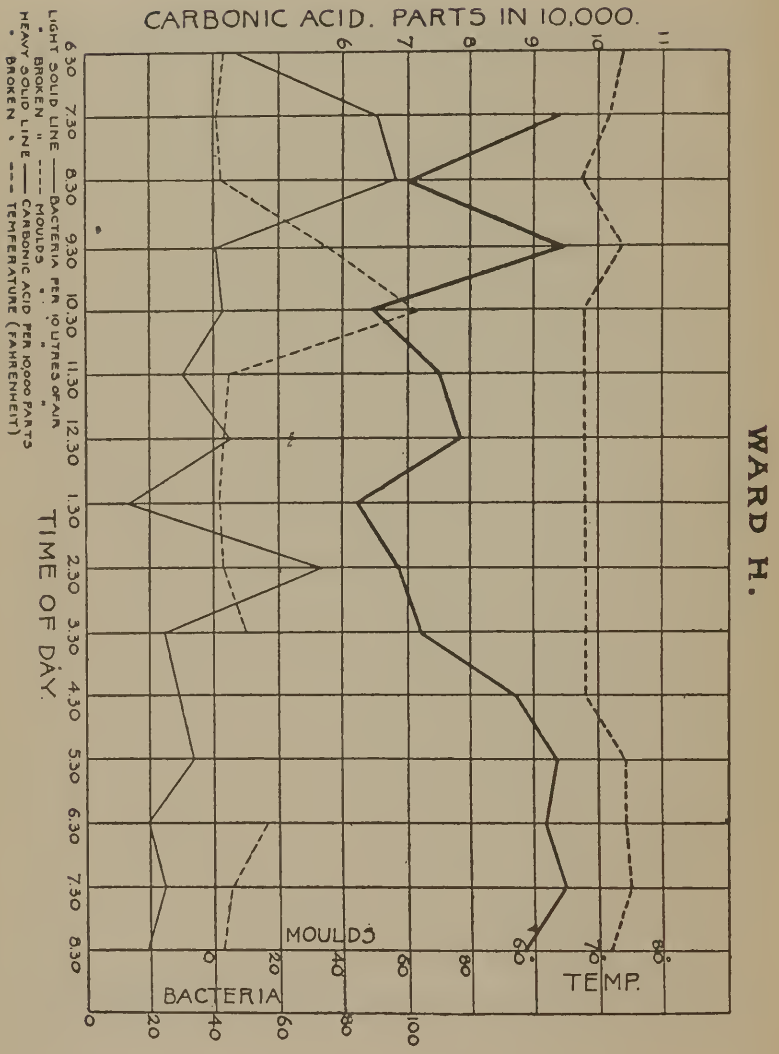
Ward F (Medical Ward, Male). Jan. 15, 1889.

Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
6.30	64	5.51	477	0	
7.30	63	6.17	106	2	Sweeping almost finished.
8.30	63	7.22	162	2	Bed-making from 7.30 to 8.30; much walking about.
9.30	64	6.81	51	25	Second sweeping nearly finished.
10.30	64	6.40	28	227	Ward in order, and quiet.
11.30	64	6.13	3	81	Ward quiet.
P.M.					
12.30	64	6.18	19	2	Ward quiet.
1.30	65	6.50	11	4	Ward quiet.
2.30	67	6.63	5	31	Thirteen visitors present.
3.30	65	7.50	20	54	Taking temperatures.
4.30	63	7.48	10	4	Quiet.
5.30	66	8.46	7	1	Quiet.
6.30	66	8.40	15	42	Quiet.
7.30	70	11.20	8	30	Quiet.
8.30	66	7.36	–	–	Quiet.
Average, .		7.10	63.7	36	
Outside air,		4.99	–	–	


WARD G.
CARBONIC ACID PARTS IN 10,000.
4 5 6 7 8 9
TIME OF DAY.
6.30 7.30 8.30 9.30 10.30 11.30 12.30 1.30 2.30 3.30 4.30 5.30 6.30 7.30 8.30
MOULDS
0 20 40 60
BACTERIA
0 20 40 60 80 100
TEMP.
60° 70° 80°
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR
" BROKEN " ---- MOULDS " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10,000 PARTS
" BROKEN " --- TEMPERATURE (FAHRENHEIT)

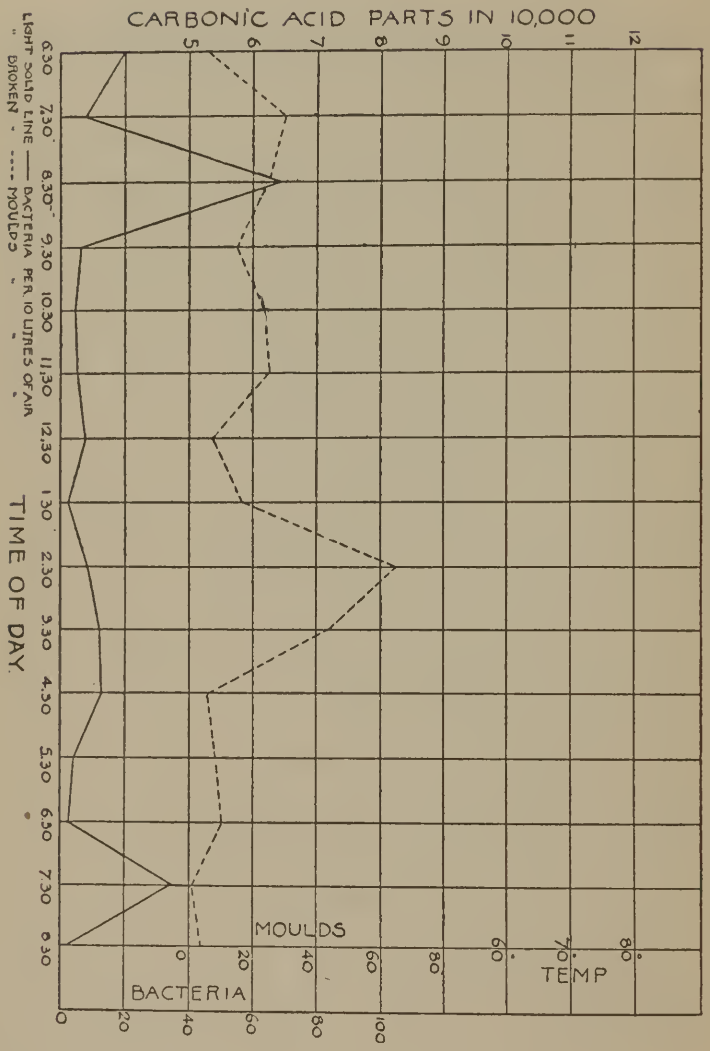
Ward G (Medical Ward, Female). Jan. 24, 1889.

Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
6.30	72	8.44	10	0	
7.30	70	6.83	28	0	
8.30	68	7.22	59	4	
9.30	68	5.21	56	1	
10.30	68	4.20	15	0	
11.30	68	5.43	7	1	
P.M.					
12.30	68	7.18	14	0	
1.30	69	7.33	11	2	
2.30	68	5.46	30	2	
3.30	68	6.15	16	6	
4.30	66	6.55	15	0	
5.30	66	5.09	14	5	
6.30	66	6.94	12	1	
7.30	66	6.63	14	8	
8.30	66	5.92	6	0	
Average, .		6.30	20.5	2	
Outside air,		4.74	–	–	


CARBONIC ACID. PARTS IN 10,000.
WARD H.
TIME OF DAY.
MOULDS
BACTERIA
TEMP.
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR
" BROKEN " ---- MOULDS " " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10,000 PARTS
" BROKEN " --- TEMPERATURE (FAHRENHEIT)

Ward H (Medical Ward, Male). Jan. 25, 1889.

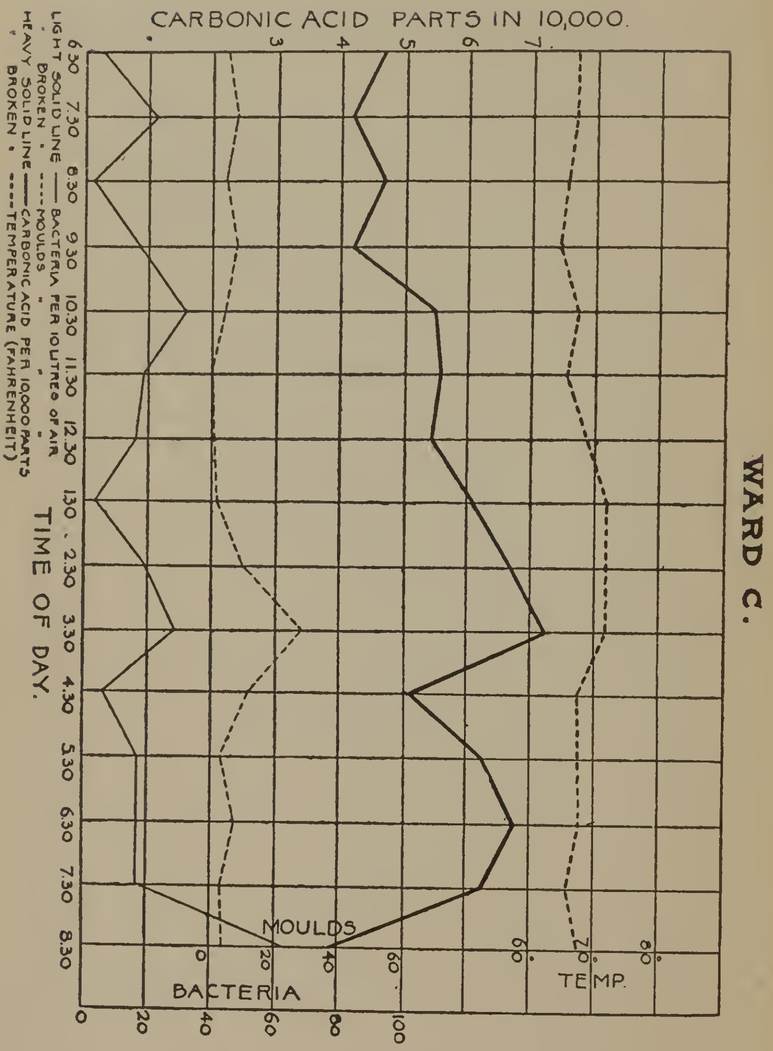
Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
6.30	74	6.58	47	3	Several beds made; patients walking about.
7.30	72	9.39	90	1	Breakfast served; making beds.
8.30	68	6.91	96	2	Floor swept.
9.30	74	9.48	40	35	Physicians' visit, with twenty-nine students.
10.30	68	6.49	43	63	Mopping floor.
11.30	68	7.62	30	5	Quiet.
P.M.					
12.30	68	7.85	45	3	Sweeping floor.
1.30	68	6.24	13	2	Quiet.
2.30	68	6.85	73	3	Considerable walking about.
3.30	68	7.23	24	10	Quiet.
4.30	68	8.71	–	–	Quiet.
5.30	74	9.37	33	–	Gas burning.
6.30	74	9.24	19	16	Some walking about.
7.30	75	9.47	24	5	Some walking about.
8.30	72	8.89	19	3	Lights out.
Average, .		8.02	43.3	11.6	
Outside air,		–	–	–	


CARBONIC ACID PARTS IN 10,000
TIME OF DAY.
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR
" BROKEN " ---- MOULDS " "
MOULDS
BACTERIA
TEMP

WARD B.

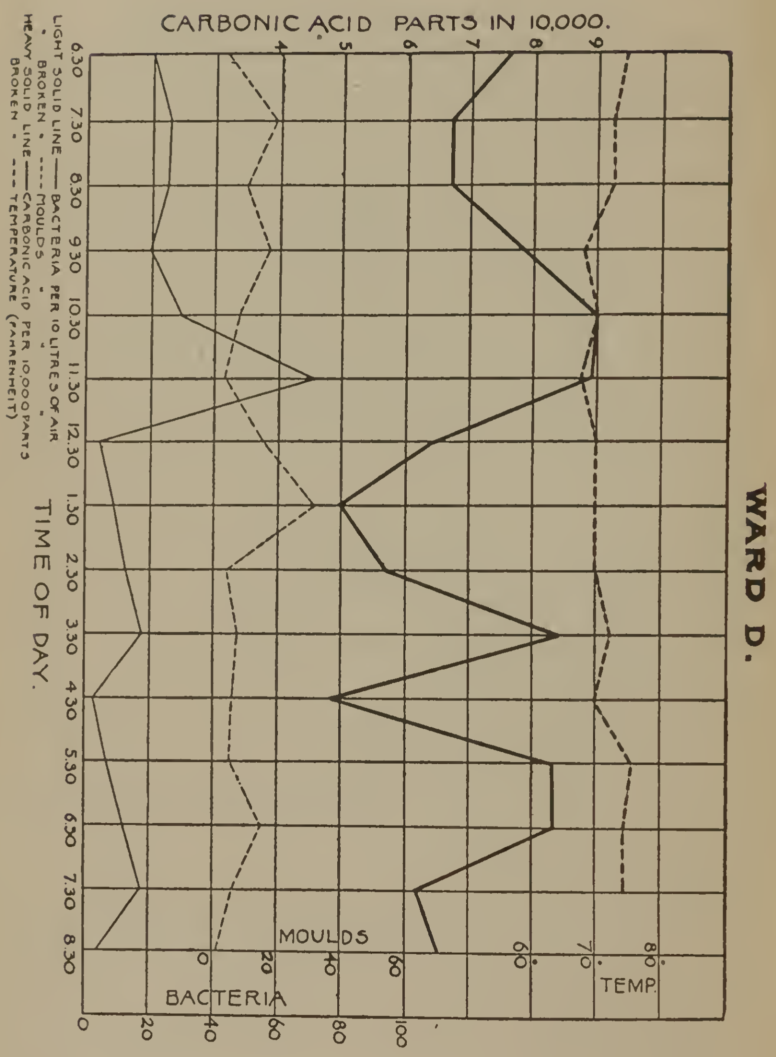
Ward B (Surgical Ward, Male). Jan. 3, 1889.

Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
7.45	63	–	20	6	End window open; making beds.
8.25	–	–	7	30	Making beds; floor swept.
9.12	–	–	68	25	End window closed.
9.30	–	–	6	15	Mopping floor.
10.30	–	–	4	23	Floor swept at 10; a few dressings changed.
11.30	65	–	5	25	Surgeon's visit; ward in order, quiet.
P.M.					
12.30	68	–	8	7	Ward swept before experiment.
1.30	–	–	2	17	Quiet.
2.30	67	–	8	65	Quiet.
3.30	67	–	12	44	Quiet.
4.30	67	–	13	6	Supper brought in.
5.30	–	–	4	8	Gas lighted; quiet.
6.30	70	–	2	10	Quiet.
7.30	73	–	34	1	Quiet.
8.30	–	–	2	4	Quiet.
9.30	–	–	2	3	Quiet.
Average, .		–	13.1	19.3	


WARD C.
CARBONIC ACID PARTS IN 10,000.
3 4 5 6 7
TIME OF DAY.
6.30 7.30 8.30 9.30 10.30 11.30 12.30 1.30 2.30 3.30 4.30 5.30 6.30 7.30 8.30
MOULDS
0 20 40 60
BACTERIA
0 20 40 60 80 100
TEMP.
60° 70° 80°
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR
" BROKEN " ---- MOULDS " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10,000 PARTS
" BROKEN " ---- TEMPERATURE (FAHRENHEIT)

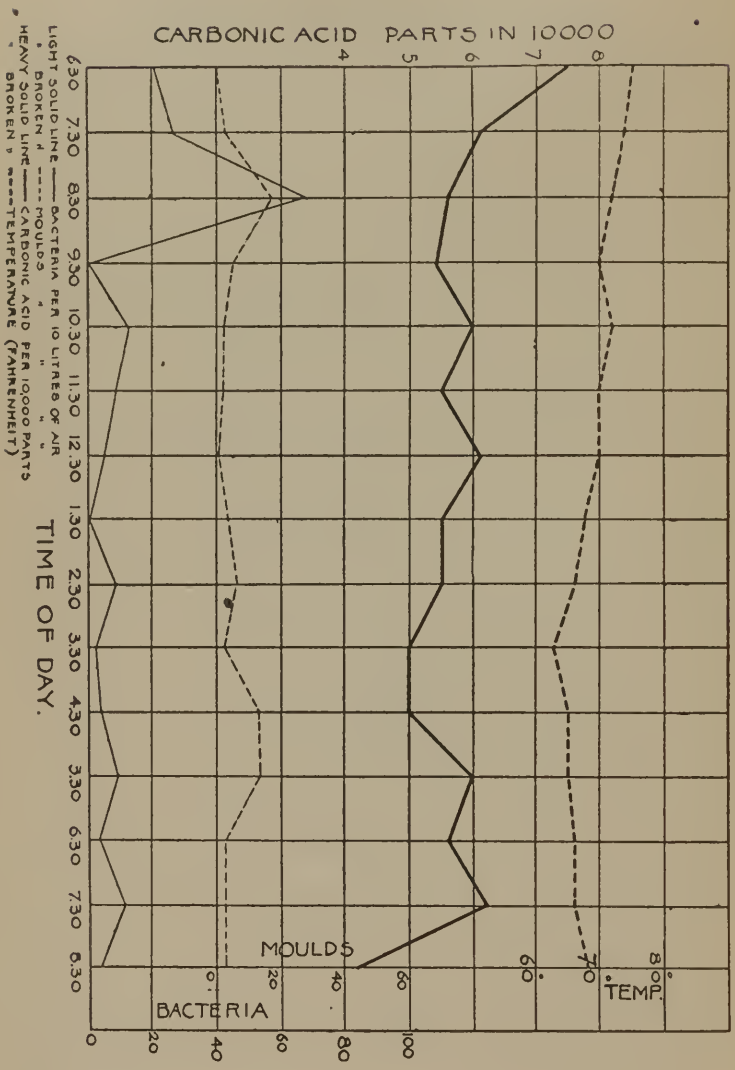
Ward C (Surgical Ward, Female). Jan. 22, 1889.

TIME.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	REMARKS.
A.M.					
6.30	67	4.74	5	5	Disagreeable smell; close; patients quiet.
7.30	67	4.17	22	7	Breakfast served.
8.30	66	4.69	2	4	
9.30	65	4.19	17	7	Floor swept at 8.45; surgical dressings; making beds.
10.30	68	5.50	31	4	Mopping floor; ward quiet.
11.30	66	5.59	18	0	
P.M.					
12.30	69	5.48	16	1	Ward swept.
1.30	72	6.13	3	2	
2.30	72	6.74	19	10	Eleven visitors present.
3.30	72	7.29	28	28	
4.30	68	5.11	6	11	Transom over door open during last hour.
5.30	68	6.33	17	3	Gas lighted at 5 10, twelve burners; patient died, and was removed.
6.30	68	6.78	16	8	
7.30	66	6.33	17	3	Four patients preparing for bed.
8.30	68	3.91	63	4	Lights out; nurse attending to duties.
Average, .		5.53	19	6.5	
Outside air,		4.18	–	–	


WARD D.
CARBONIC ACID PARTS IN 10,000.
TIME OF DAY.
MOULDS
BACTERIA
TEMP.
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR
" BROKEN " ---- MOULDS " " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10,000 PARTS
BROKEN " --- TEMPERATURE (FAHRENHEIT)

Ward D (Surgical Ward, Male). Jan. 23, 1889.

Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
6.30	74	7.63	21	3	
7.30	72	6.74	26	19	
8.30	72	6.69	25	10	Ward in disorder; making beds; floor dirty; very close; opened end window.
9.30	68		19	17	Ward swept about 9.
10.30	70	9.00	30	8	
11.30	68	8.90	72	4	Surgeon's visit between 10 and 11; all dressings changed.
P.M.					
12.30	70	6.38	3	15	Patients eating dinner.
1.30	70	5.01	9	31	
2.30	70	5.70	13	4	End door closed.
3.30	72	8.39	18	8	End door open.
4.30	70	4 88	2	6	Supper brought in.
5.30	75	8.31	7	6	Gas lighted.
6.30	74	8.32	13	15	Dressed amputation.
7.30	74	6.24	18	6	Much walking about; patients preparing for bed.
8.30	70	6.49	3	1	Lights turned down at 7.45.
Average, .		7.05	18.6	10.4	
Outside air,		4.17	–	–	

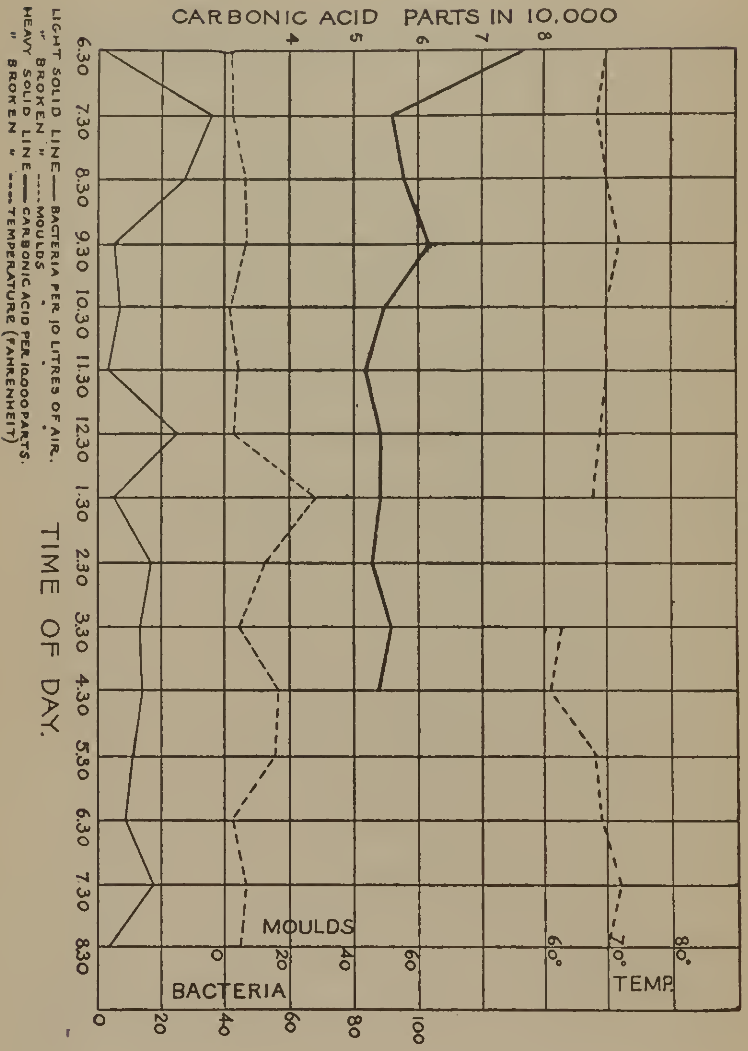

CARBONIC ACID PARTS IN 10000
4 5 6 7 8
6.30 7.30 8.30 9.30 10.30 11.30 12.30 1.30 2.30 3.30 4.30 3.30 6.30 7.30 8.30
TIME OF DAY.
MOULDS
0 20 40 60
60° 70° 80°
TEMP.
BACTERIA
0 20 40 60 80 100
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR
" BROKEN " ---- MOULDS " " " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10,000 PARTS
" BROKEN " ---- TEMPERATURE (FAHRENHEIT)

WARD P.

Ward P (Surgical Ward, Male). Feb. 1, 1889.

Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
6.30	75	7.54	21	0	Several patients up.
7.30	74	6.09	26	2	Breakfast served.
8.30	72	5.63	67	17	Sweeping floor; cold-air inlets opened a little.
9.30	70	5.39	0	5	Ward in good order.
10.30	72	5.95	12	2	Ward in good order.
11.30	70	5.49	8	2	Some draught.
P.M.					
12.30	70	6.12	5	1	Second sweeping finished.
1.30	68	5.47	1	3	Quiet.
2.30	66	5.51	9	6	Fifteen visitors present.
3.30	63	5.01	2	2	
4.30	65	4.98	4	13	Very quiet.
5.30	65	6.04	9	13	Fifteen gas jets burning.
6.30	66	5.56	3	2	Very quiet.
7.30	66	6.21	11	2	Very quiet.
8 30	68	4.19	3	2	Lights out.
Average, .		5.68	12	4.7	
Outside air,		4.45	–	–	

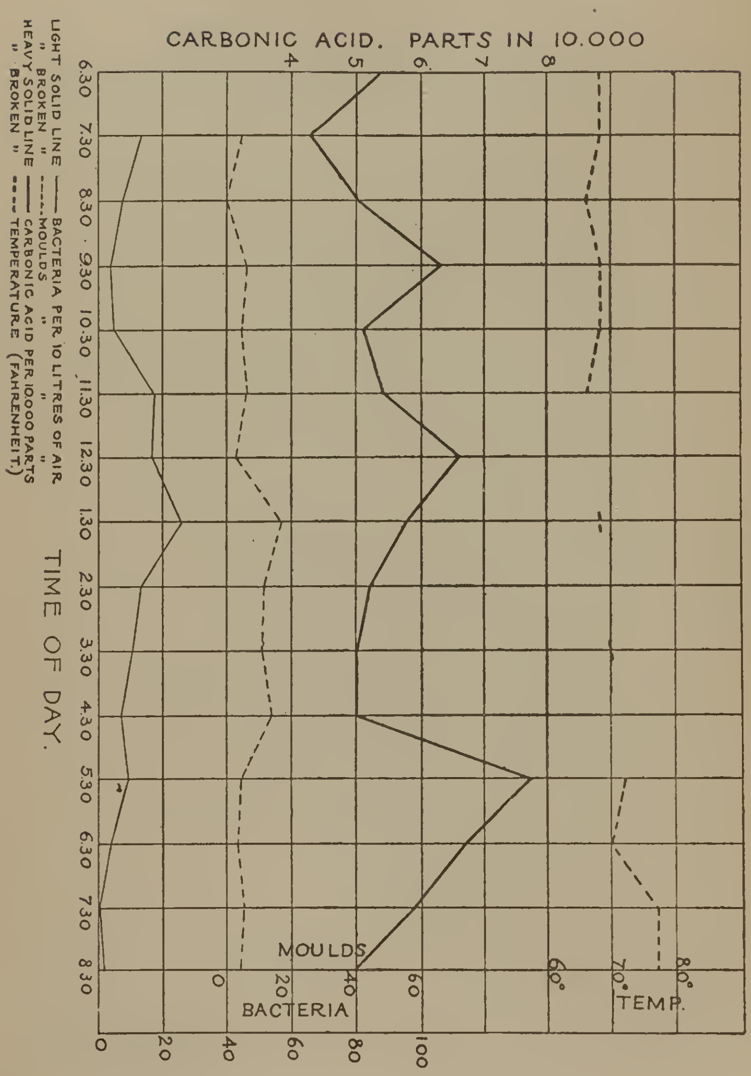
WARD T.


CARBONIC ACID PARTS IN 10,000
4
5
6
7
8
6.30 7.30 8.30 9.30 10.30 11.30 12.30 1.30 2.30 3.30 4.30 5.30 6.30 7.30 8.30
TIME OF DAY.
MOULDS
0
20
40
60
BACTERIA
0
20
40
60
80
100
60°
70°
80°
TEMP.
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR.
" BROKEN " ---- MOULDS " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10,000 PARTS.
" BROKEN " ---- TEMPERATURE (FAHRENHEIT)

Ward T (Medical Ward, Male). Feb. 2, 1889.

Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
6.30	70	7.67	3	2	
7.30	69	5.63	35	2	Making beds.
8.30	70	5.77	27	6	Making beds.
9.30	72	6.16	5	6	Felt close; ventilators in ceiling closed.
10.30	70	5.49	7	1	Felt fresher; quiet.
11.30	70	5.21	3	4	Quiet.
P.M.					
12.30	69	5.39	25	3	Some walking about.
1.30	68	5.35	5	28	Some walking about.
2.30	–	5.36	17	12	Some walking about.
3.30	63	5.56	13	4	Taking temperature; cold; closed two ventilators in ceiling.
4.30	61	5.44	14	16	Supper brought; closed all ceiling ventilators but one.
5.30	68	–	11	15	Fifteen gas jets burning; some work.
6.30	69	–	9	2	Pretty quiet.
7.30	72	–	18	6	Quiet.
8.30	70	–	3	4	Quiet.
Average, .		5 72	13	7.4	

WARD E.


CARBONIC ACID. PARTS IN 10.000
4 5 6 7 8
6.30 7.30 8.30 9.30 10.30 11.30 12.30 1.30 2.30 3.30 4.30 5.30 6.30 7.30 8.30
TIME OF DAY.
MOULDS
0 20 40 60
BACTERIA
60° 70° 80°
TEMP.
0 20 40 60 80 100
LIGHT SOLID LINE —— BACTERIA PER 10 LITRES OF AIR.
" BROKEN " ----- MOULDS " " "
HEAVY SOLID LINE —— CARBONIC ACID PER 10000 PARTS
" BROKEN " ---- TEMPERATURE (FAHRENHEIT.)

Ward E (Contagious Ward, Diphtheria). Jan. 26, 1889.

Time.	Temperature, Degrees.	Carbonic Acid.	Bacteria.	Moulds.	Remarks.
A.M.					
6.30	68	5.38	no	count	E, South.
7.30	68	4.28	13	5	Making beds; ward swept; E, North.
8.30	66	5.00	7	0	E, South.
9.30	68	6.25	3	6	E, North.
10.30	68	5.12	4	5	Mopping floor; E, South.
11.30	66	5.44	17	6	Mopping floor; E, North.
P.M.					
12.30	–	6.58	6	3	E, South.
1.30	68	5.83	26	17	E, North.
2.30	–	5.17	12	11	
3.30	70	5.04	10	11	
4.30	–	5.02	7	14	
5.30	72	7.65	9	5	
6.30	70	6.67	3	3	
7.30	77	5.91	0	5	
8.30	77	4.97	1	4	
Average, .		5.06	7.2	6.4	
Open air, .		3.89			

Carbonic Acid and Micro-organisms.

Hourly determinations of carbonic acid in the nine wards examined show a most satisfactory condition.* According to the standard usually adopted, the ventilation in all the wards examined is good, and in most of them perfect.

Although no relation exists between the amount of carbonic acid and the number of micro-organisms found in individual experiments, the wards which showed the best average results in carbonic acid are also freest from micro-organisms.

Moulds.

Heretofore, but little has been said concerning moulds, bacteria being, from a sanitary point of view, of much more importance. There are fewer moulds present in the air of the wards than bacteria, and they fail to fall into line with them in their distribution throughout the day. On the whole, they fluctuate more than bacteria, and the cause of a sudden increase or decrease in numbers is not so easily traced to causes within the room. The stirring up of the dust by sweeping and bed-making does not appear to materially increase their number, for where an increase in bacteria from such causes is most marked, the moulds are conspicuously absent; when an increase does appear to be due to sweeping, etc., the rise in numbers always follows later than the bacteria. The fact that these large disturbances do not increase the number of moulds, shows that they have not subsided, and illustrates the well-known fact that moulds are relatively lighter than bacteria, and consequently do not settle out so readily. The great buoyancy of moulds is also shown by the determinations made in the basements, where disturbing influences seldom enter, and yet comparatively large numbers were always found suspended in the air.

While the bacteria are distinctly greater in numbers during the morning, moulds, on the other hand, show a tendency to increase in the afternoon; thus, in the nine wards examined by hourly experiments, the moulds in six predominate in the afternoon. It is probable that the moulds, being so light, are kept suspended longer in the upper por-

* Pettenkoffer's method was employed in all determinations of carbonic acid.

tions of the room by the commotion of the morning. This condition being removed, the tendency is to fall; but if met by air currents of sufficient force, they again take an upward course, and thus cause the fluctuations so frequently met with.

Conclusions.

The results obtained from buildings of the hospital group occupied by employees, investigated for the sake of comparison with the wards, taken together with the results furnished by outside air, furnish abundant proof that the air of the hospital is remarkably free from micro-organisms. Whether the numbers found are greater or less than would be found in similar institutions, is not known. So far as I am familiar with the work of other investigators in this field, the results show that hospitals of this class, as compared with other buildings, will take first rank in the freedom of their air from micro-organisms.

This is as it should be: bacteria, in a way, represent so much dirt. In a well-managed hospital, one has an approach to an ideal degree of cleanliness, and in no class of buildings is the same care taken to secure freedom from dirt as is taken in such a hospital. Undoubtedly, the systematic, thorough renovation which is going on continually in the hospital, is of great importance in removing accumulations of germs, which must inevitably occur in the wear and tear of a building. This hospital is particularly fortunate in this respect; with its large tent service, wards in turn can be vacated during the summer months, and put in thorough repair, to an extent not otherwise possible.

In this connection, it will be interesting to reproduce some valuable tables prepared by Prof. Thos. Carnelly and his colleagues,* showing the number of micro-organisms in the air of clean and unclean buildings in Dundee.

	Bacteria in 10 litres of air.
One-roomed houses, clean,	180
" " dirty,	410
" " dirtier,	490
" " very dirty,	930

* I take great pleasure in referring the reader interested in this subject to the work of Carnelly, it being the first attempt, so far as I am aware, to systematically determine the number of micro-organisms in the air of buildings.

	Bacteria in 10 litres of air.
Naturally ventilated schools, cleaner, ...	910
" " " average cleanliness, . .	1,250
" " " dirtier, ...	1,980
Mechanically ventilated schools, cleanest, . . .	30
" " " clean, ...	160
" " " less clean, . . .	300

These results leave no doubt that the cleanliness of rooms and of persons also is of the greatest importance in preventing accumulations of micro-organisms. It will be noticed that the numbers found in mechanically ventilated schools are far less than for those ventilated naturally; but the results as a whole, both in schools and dwelling-houses, are enormous, as compared with those obtained in this hospital. On the other hand, Carnelly found in the wards of the Dundee Royal Infirmary, between 4 and 5 o'clock P.M., from ten to twenty bacteria. Neumann (Vierteljahrsschrift f. gerichliche Medicin, 1886. B. 14, p. 30) made thirty-five experiments by Hesse's method. At different elevations, from 1.40 to 3.20 metres, about the same number of organisms were found. In the morning, after sweeping, 10 litres of air gave from 80 to 140 bacteria, while four consecutive determinations at the same height showed a gradual decrease; the last examination, at 8 P.M., giving from 4 to 10 bacteria.

The results obtained in both the above hospitals are in perfect accord with those obtained in this investigation.

The extent of vitiation which the air of dwelling-houses may reach is further shown by determinations made by Carnelly, on one, two and four roomed houses, between 12.30 and 4.30 A.M.

	Bacteria.	Moulds.
One-roomed houses, ...	580	12
Two-roomed houses, ...	430	22
Four-roomed houses, and more, ...	160	10

When it is remembered that the air of the Boston City Hospital is practically free from bacteria at the hour of midnight, the above results, representing the condition of the air breathed by human beings, is certainly startling, and goes far to show the value of the information furnished by such determinations. The atmosphere of a building vitiated by micro-organisms can be so readily brought at least to a moderate state of purity, by a proper degree of cleanliness and oversight, that there is no legitimate reason why the air of public buildings should reach the condition of vitiation shown by Carnelly's experiments, in certain buildings in Dundee.

In any comparison of the number of micro-organisms found in the air of a hospital with those of other buildings, allowance must of course be made for the fact that a very small number of organisms found in hospital air, if pathogenic, might be more dangerous than large numbers of non-pathogenic forms found elsewhere. The great majority of micro-organisms found in air are probably harmless; but their functions as yet are so imperfectly understood, that it would seem unwise to consider them entirely harmless. Many of them evince a power in the decomposition of the various culture media, which is suggestive of what might happen in or upon the human system, should they find there a suitable *nidus* for development. Although no attempt was made in this investigation, except in a very general way, to determine the character of the germs present, it was found that the same species which occurred in the outside air were met with in the hospital; but certain species were met with in the hospital that were not found in outside air. In the ward devoted to diphtheria, species were always fewer in number than elsewhere, and the colonies were not unlike those obtained from the material furnished by the patients themselves, although no proof of their identity was obtained. The presence of pathogenic bacteria has frequently been demonstrated in the air of hospital wards; for example, Cornet, of Koch's Hygienic Institute, found bacilli tuberculosis in fifteen out of twenty-one wards in seven hospitals in Berlin, and out of ninety-four animals inoculated, twenty died of tuberculosis. Von Eiselsberg (Langen-

beck's Archiv. B. 35, heft. 1), in an erysipelas room of the hospital, found erysipelas cocci; also, in a surgical ward, where wounds were treated under aseptic precautions, the presence of Staphylococcus Pyogenes Aureus was demonstrated. Emmerich (Deutsch. Med. Wochenschrift, 1887, No. 3) not only found erysipelas cocci in the air of an old dissecting room, but also in the plastering and walls and ceiling.

In this connection, it should be stated that the ordinary methods employed in the cultivation of the germs of the air would fail to reveal the presence of certain pathogenic bacteria, as, for example, bacilli tuberculosis; such forms, however, are not difficult to determine by special means. Pathogenic bacteria are as likely to exist in this hospital as in any other, and probably do exist; but it is worthy of note that the general health of employees is excellent, that contagious diseases are seldom contracted by them, or by patients themselves, although isolated cases occasionally occur.

The importance of obtaining definite information regarding the dangerous or innocuous character of micro-organisms found in the atmosphere is evident; but, until methods are so amplified that species can be identified with a greater degree of certainty and far less expenditure of time than at present, we must be content with a determination of the number and distribution of bacteria in the air of buildings.

Carnelly has proposed a standard for the air of dwellings and schools; *i.e.*, twenty micro-organisms per litre, or two hundred per ten litres (excess over outside air), — numbers so greatly in excess of all results obtained in this hospital as to make evident the necessity of a standard for various classes of buildings.

The air of this hospital compares favorably with the external air. In the absence, then, of a standard of purity for hospital air, it would not be unreasonable to require that the number of micro-organisms in the air of a ward should but slightly exceed the numbers found in outside air.

In conclusion, the writer wishes to express his gratitude to the trustees of the hospital for aid in carrying on this work, and to the superintendent, Dr. Rowe, for encouragement in the undertaking.